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POST-TRAUMATIC PAINFUL OSTEOPOROSIS

A CLINICAL AND ROENTGENOLOGICAL ENTITY*

By LOUIS G. HERRMANN, M.D., HAROLD G. REINEKE, M.D., *and* JOHN A. CALDWELL, M.D.

CINCINNATI, OHIO

ROENTGENOLOGISTS are aware of the fact that the osseous framework of the body may undergo rapid and extensive physicochemical changes as the result of alterations or abnormalities of innervation or of blood supply to an extremity, yet only a few attempts to correlate the clinical facts with the roentgenologic changes have been made since 1900 when Sudeck[16] first described the trophic changes in the bones of the hands and feet which may result from trauma to the extremity.

Sudeck's[16,17] first report described acute atrophy of bone which he found associated with inflammatory processes in the articulations but later he[18] described a type which he called *post-traumatic reflex atrophy of bone*. He clearly differentiated between this reflex atrophy of bone and the type of bone atrophy described by Virchow, Charcot and others as the result of tabes dorsalis, syringomyelia or other central nervous system disease.

In 1901 Kienböck[11] added further to the clinical description of the disease entity and he gave an accurate description of the roentgenologic changes which take place in the small bones of the extremity. Both Sudeck and Kienböck demonstrated clearly that inactivity alone could not account for such a severe degree of osseous changes and particularly that these changes in bone occurred more quickly than those which characterize the atrophy of disuse and usually appeared while the extremity was still in use.

It is well known that bones of extremities which have been kept at rest for any considerable length of time usually lose much of their mineral salts; consequently, they become more permeable to the roentgen rays. This type of bone atrophy is of comparatively little importance since the bones rapidly regain their normal density and strength when the normal function of the extremity is resumed. During the period when the atrophy of the bones is marked the patient does not complain of any symptoms which might be referable to the absorption of the mineral salts from these bones.

In order to avoid all confusion with atrophy of bone due to inactivity or disuse we wish to emphasize that *true osteoporosis* is that type of atrophy of bone which is characterized by a patchy demineralization of the bones of an extremity in which there are coexisting signs of vasomotor insta-

* From the Department of Surgery of the College of Medicine of the University of Cincinnati and the Cincinnati General Hospital. Read at the Forty-second Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23–26, 1941.

bility, trophic changes in the soft tissues and usually severe visceral pain. The expression "*acute bone atrophy*" only adds to the general confusion since the word "atrophy" usually brings to the mind of the clinician a more or less uniform loss of tissue of a part. On the other hand, the expression "painful osteoporosis" immediately suggests to the clinician that he is dealing with a painful syndrome in which the affected bones are "full of pores." We believe that this expression "post-traumatic painful osteoporosis" is the more logical one to use when we refer to this syndrome which frequently follows trauma to some multi-articular joint.

FIG. 1. Photograph showing the trophic changes in the skin, the edema of the hand and the degree of impairment of function in acute post-traumatic osteoporosis.

The importance of post-traumatic painful osteoporosis as a major cause for prolonged loss of function or severe aching pain after trivial as well as serious injury to an extremity is not generally recognized and, as a result, many innocent persons are unjustly accused of malingering or of being grossly uncooperative simply because their disability continues long after the effects of the original trauma have subsided or after the broken bones have had a chance to become firmly united in good position.

Some surgeons have displayed their lack of understanding of this disease entity by recommending very heroic measures such as surgical removal of the extremity for its cure. Other surgeons have failed to recognize the syndrome as post-traumatic osteoporosis or have frequently delayed active treatment until permanent changes in the bones were present because they considered the syndrome as one of the "minor causalgias." We have observed several patients in whom the original post-traumatic osteoporosis was considered a "minor causalgia" and in an effort to relieve the pain such procedures as the injection of alcohol into the median nerve, the attempted neurolysis of the median nerve or the resection of some of the great nerves of the extremities all resulted in intractable pain in the affected extremity and its usual sequel, the addiction to narcotic drugs.

Roentgenologists are the first to have the opportunity of recognizing this important complication to injury for the so-called minor causalgias do not produce osseous changes of the type which characterize true osteoporosis. The early recognition of these specific roentgenologic changes in the small bones of the affected extremity is absolutely essential if the period of disability is to be favorably influenced by active therapy. A long period of disability is a great economic loss to the patient as well as to his employer; consequently, we must make every effort to stop the destructive process in the bones before irreparable damage to the affected bones has taken place.

CLINICAL ASPECTS

Post-traumatic osteoporosis is always characterized by (*a*) partial loss of motor function of the affected part; (*b*) mild to severe vasomotor and trophic changes in the affected extremity; (*c*) spotty demineralization of the bones near the site of trauma; and (*d*) mild to severe aching pain in the extremity. The disturbances of function are always more extensive than can be explained on the basis of the trauma alone (Fig. 1), and the aching pain in the extremity is greatly out of proportion to the local signs of injury to the tissues. If we disregard the local effects of the trauma in these patients, we must still be impressed by the extensive loss of motor function and the obvious vasomotor and trophic manifestations which are present in such ex-

tremities. The aching pain which forms such an important part of this clinical syndrome cannot be relieved by immobilization of the part; while the pain associated with simple trauma, fracture of one or more of the bones of an extremity, or even tuberculous, pyogenic or specific osteoarthritis, is definitely relieved by immobilization of the affected extremity.

The type of trauma which precipitates the post-traumatic osteoporosis may vary in severity and kind, and because the clinical course of the disease is frequently altered by the intensity of the trauma and the extent of the injury to the bones or to the articulations, more care must be exercised in differentiating this reflex trophic disturbance from other affections of the bones. We usually divide the cases of acute painful osteoporosis in three clinical groups as follows:

Group 1. Painful osteoporosis which follows slight or moderate trauma to one of the polyarticular regions, wrist or ankle. The osteoporosis comes on gradually over a period of three or four weeks and the patient develops edema of the extremity and pain on moving the joints. Little or no importance is usually attached to the original trauma. The limitation of motion in the neighboring joints rapidly becomes the outstanding symptom and with this increase in functional disability further immobilization of the part increases the pain. The differential diagnosis between acute osteoporosis and tuberculous osteoarthritis is usually difficult at this stage. The spotty demineralization of all the small bones of the affected extremity (Fig. 2) without other evidence of tuberculosis is of some significance, yet during certain phases of the two processes the type of local destruction of bone may be identical. The other types of neurotrophic disturbances in bone do not present roentgenologic findings which might be confused with true osteoporosis.

Group 2. In this group we usually place those patients in whom the osteoporosis follows an injury to the articular or peri-

Fig. 2. Roentgenogram showing patchy demineralization of the bones of the hand and wrist. These changes are characteristic of the acute stage of post-traumatic painful osteoporosis.

articular tissues when the injury is of sufficient magnitude to cause fracture of one or more of the bones of that extremity. In these patients the trauma is usually considered the major cause for the pain as well as the local vasomotor changes.

We believe that any patient whose pain is not relieved by proper reduction of the fractured bones with satisfactory immobilization of the injured part should be seen regularly and roentgenograms should be made at intervals of about two weeks and carefully studied for the pathognomonic signs of true osteoporosis. We have found that it is important to have the normal hand or foot on the same roentgenogram so accurate comparison of the structure of the bones can be made (Fig. 3). It is extremely difficult to make an absolute diagnosis of osteoporosis in the very early stage from

FIG. 3. Roentgenogram showing both hands taken at the same time so that accurate comparison of the osseous changes can be made. Note the early acute osteoporosis in the bones of the right wrist.

the clinical study of the affected extremity alone; therefore, the roentgenogram becomes a very necessary aid in the study of the patient.

Group 3. In those patients who complain of constant pain after slight or moderate trauma to the soft parts about a joint, the presence of a low grade myositis or chronic tenosynovitis must be considered as a possible cause for the pain. Tonic contractions of the muscles of the extremity with tenderness of the muscles or tenderness in the region of the joints are more suggestive of affections of the soft tissues only. This type of disturbance usually belongs to the group called minor causalgia but these patients should be re-examined at regular intervals to rule out the presence of true osteoporosis. The roentgenogram will usually supply the information necessary for the differential diagnosis since the bones of the affected extremity will certainly show the diffuse mottling which is so characteristic of the early stages of osteoporosis (Fig. 2).

SITE AND FREQUENCY

Osteoporosis is most frequently found in the short bones of the hands and feet. Next in order of frequency are the epiphyses of metatarsals, metacarpals and phalanges, and then the epiphyses of long bones. The diaphyses of long bones are rarely involved. The flat bones of the skull may also be the seat of similar rarefaction. In 1929 Schüller[15] reported typical examples of post-traumatic osteoporosis of the skull.

Moreau-Gimelli[12] (1912) and Delorme[1] (1917) analyzed a total of 7,400 roentgenograms which had been taken because of trauma to one or more of the extremities and found only 115 cases (1.5 per cent) of atrophy of the bones. During World War I, Delorme[2] reported 62 cases of osteoporosis from a series of 178 cases of trauma to bones, and later he analyzed 1,350 additional roentgenograms of the same type. Delorme concluded from these series of cases that osteoporosis existed in 50 per cent of the cases where the trauma affected the small bones of the hands or feet; 20 per cent after trauma to the distal phalanges and 50 per cent of the cases in which both bones of the leg were fractured. In the cases of fracture of the bones of the forearm, he concluded that one-third of the cases of fracture of one bone and two-thirds of the cases in which both bones were fractured developed true osteoporosis. Guarini[4] (1918) came to the same conclusions after studying a large series of roentgenograms. Such statistics, however, refer only to the number of cases which show decalcification of the bones in the roentgenograms, and do not take into consideration the equally important clinical signs of the disease. The incidence of osteoporosis in civil life is decidedly less than studies made during World War I would lead us to believe.

Noble and Hauser[14] (1926) reported 48 cases from the Mayo Clinic during the period from 1912 to 1924. One case presented osteoporosis in the shoulder, 5 showed changes in the hand, and 41 had the process in the foot. The ages of the patients varied from nineteen to sixty-four years.

Fontaine and Herrmann[3] (1933) presented 22 cases between the ages of seventeen and sixty-five in which the process was present in the shoulder in 6 cases, in the

hand in 8 cases, and in the foot in 8 cases. Gurd[5] (1934) published his series of 24 cases between the ages of twenty-one and fifty-eight in which the shoulder was involved in 2 cases, the hand showed changes in 6 cases, and the remaining 16 showed the process in the foot. The disease entity apparently occurs with equal frequency in both sexes and among all races of people. It has never been reported in young children but does occur frequently in the latter decades of life.

Henderson[6] (1936) reviewed the cases of osteoporosis at the Mayo Clinic from 1930 to 1934, inclusive, and found 55 cases. In 8 of these, acute atrophy occurred in the hand, and in 47 in the foot and ankle. In 18 of these 47 cases, atrophy was definitely connected with trauma; in the remainder, it could not be definitely classified as to etiology, although Henderson believed infection, disuse, or arthritis might have been a factor in some of the cases.

Fig. 4. Roentgenogram showing the late acute form of post-traumatic osteoporosis. Cortex of the small bones is very thin and outlines of the bones are faint.

Fig. 5. Roentgenogram showing the chronic form of post-traumatic osteoporosis. The patchy areas of rarefaction have largely disappeared.

Herrmann and Caldwell[9] (1941) reviewed the cases of post-traumatic osteoporosis at the Cincinnati General Hospital from 1932 to 1940 and found 84 cases. All of these cases followed trauma and 58 showed involvement of the bones of the wrist and 26 showed involvement of the bones of the ankle. Of the entire series of 84 cases they found 34 in the acute stage and these 34 were treated by periarterial sympathectomy. Of these 84 cases of osteoporosis 12 of them followed prolonged exposure to cold (frost bite).

ROENTGENOLOGIC ASPECTS

Two main forms of osteoporosis have been described as showing constant and characteristic changes in the roentgenograms. Sudeck named these apparently distinct stages in the evolution of the disease, (*a*) the acute form and (*b*) the chronic form.

(*a*) The so-called acute form is characterized by a mottled appearance of the bones due to the irregular rarefied areas in the spongiosa. This mottling is usually most marked in the carpal and tarsal bones and in the heads of the metacarpal and metatarsal bones (Fig. 2). In advanced cases the cortex of the small bones becomes very thin and the outline of the individual bones is frequently lost. The lamellae fade into one another and produce an ill defined

or homogeneous shadow in the roentgenogram (Fig. 4).

(*b*) In the so-called chronic form, the trabeculae of the bones are very fine and sometimes difficult to recognize. The limits of the individual bones again become demonstrable, but there still remains a general loss of mineral salts. The patchy areas of rarefaction have largely disappeared. The increased strength of the bone is due to a thickening of the longitudinal lamellae since the horizontal lamellae remain very thin (Fig. 5).

In cases of osteoporosis of the short bones, especially the carpal and the tarsal bones, there are three stages in the evolution of the disease. These three stages are: (*a*) the onset; (*b*) the height of the disease; (*c*) the reorganization.

Each of these three stages presents characteristic roentgenologic changes. This evolution of the disease from the standpoint of the roentgenologic changes can best be portrayed as follows: In the period of onset there is a general mottled appearance of the bones (Fig. 6). The outlines of the bones are still easily discernible. The rarefaction continues to become more marked and more extensive. The irregular areas of rarefaction soon disappear and the bones become uniformly permeable to the roentgen rays.

This stage of diffuse and marked demineralization marks the height of the disease. The absorption of the bone seems to spread to the neighboring bones and thus involves the heads of the metacarpals or metatarsals, then the phalanges and finally, the adjoining ends of the radius and ulna or the tibia and fibula as the case may be (Fig. 2). Marked thinning of the cortex of the bones has taken place and longitudinal streaks have made their appearance in the thinned cortex. In the region of the carpal and tarsal bones this thinning of the cortex of the bones results in the disappearance of the limits of the bones and thus transforms the entire area into a homogeneous mass which is very permeable to the roentgen rays. It is at this stage that a diagnosis of tuberculous osteoarthritis is frequently made.

Fig. 6. Roentgenogram showing the early general mottling of the bones which characterizes the onset of post-traumatic osteoporosis.

During the period of reconstruction there is a slow reappearance of the calcium in the bones. In most cases complete recalcification never takes place.

Roentgenograms taken during this stage show that the limits of the small bones have again become visible and the longitudinal lamellae have become thickened (Fig. 5).

The duration of each of these stages is very variable. The factor of time seems to be of little importance. In general, however,

the first two stages are relatively rapid in their evolution, while the third or reconstructive stage is usually extremely slow. *Complete anatomical restoration of the density of the bone, however, is not necessary for complete symptomatic relief.*

CLINICAL EVOLUTION

Many clinicians believe that post-traumatic painful osteoporosis is a self-limited disease and that after a few weeks or months, recalcification takes place without leaving any serious deformities. Sudeck stated that favorable evolution is only occasionally seen, and it is not the usual end-result of the disease entity. It has been our experience that after the disease has reached the climax or stage of almost complete decalcification, the process of recalcification may begin spontaneously, but years later the roentgenograms may still show thinning of the cortex of the bones and thin lamellae containing irregular areas of recalcification. From these facts one might get the impression that the disease heals spontaneously since it is also well known that the vasomotor manifestations and pain may disappear without adequate treatment. In such cases, however, the recovery of function of the extremity requires many months and frequently during the stage of recalcification extensive fusion of the carpal or tarsal bones takes place. This ankylosis usually causes great economic loss to the patient. Undoubtedly many of the mild forms of post-traumatic osteoporosis do heal spontaneously and give no permanent disturbance of function; therefore, one must be careful not to assume that some particular form of therapy used in any one patient is a true remedy for the disease entity under all circumstances.

TREATMENT

The treatment of post-traumatic osteoprosis has, until recently, been symptomatic and preventive rather than curative in nature. Sudeck recommended minimum immobilization and then active movement in most of his cases. In 1926, Noble and Hauser[14] recommended heat to the point of tolerance either in the form of radiant heat or paraffin baths. They also advised massage and voluntary motion of the joints in spite of a little pain, *but they emphasized that forceful manipulation under anesthesia was definitely contraindicated.* Any form of fixation with plaster of paris casts or orthopedic apparatus causes increased pain to the patient. Delorme recommended treatment by thyroid and parathyroid extracts and Pech advised heliotherapy.

In 1924, Heyman[10] suggested periarterial sympathectomy for the treatment of painful osteoporosis. He reported prompt relief of pain and restoration of function following the operation.

The recommendation by Mumford[13] (1938) concerning roentgen therapy for post-traumatic painful osteoporosis was given serious consideration and diligent application in our clinics for we were also hopeful that some such treatment would prove effective and could then be easily made available to all who suffered from this disabling disease. The pain of acute osteoporosis can be greatly lessened or completely relieved by the roentgen therapy as outlined by Mumford but careful follow-up studies upon the 18 patients with acute osteoporosis whom we have treated by roentgen therapy alone have shown that the destruction of bone continues and the disturbance of function is unaltered and we have concluded that the period of disability is not greatly shortened by roentgen therapy. Intensive physiotherapy and especially functional stimulation of the extremity as suggested by Gurd gives end-results which are comparable to those which we have observed after roentgen therapy.

Our own clinical studies[7,8,9] have convinced us that the course of post-traumatic painful osteoporosis can be greatly shortened and most of the serious complications avoided if the disease is recognized in the acute phase and treated by thorough denudation of the main artery to the affected extremity (periarterial sympathec-

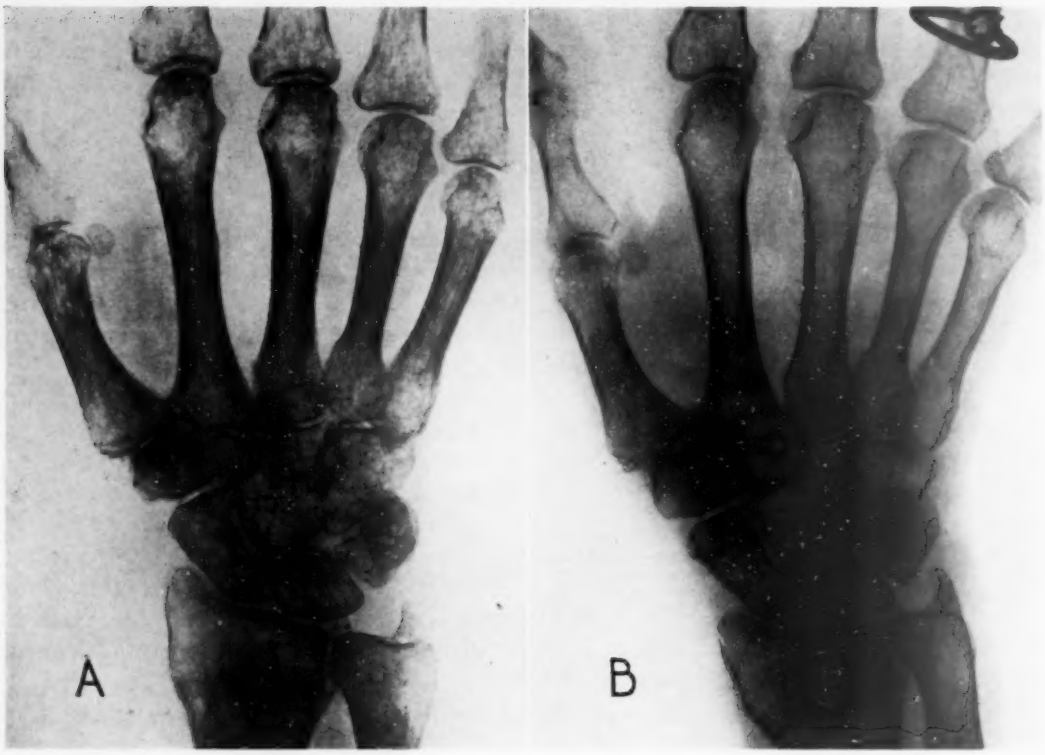

FIG. 7. Roentgenograms showing the effect of periarterial sympathectomy upon post-traumatic osteoporosis which was still in the active or acute stage of evolution of the disease. *A*, one month after Colles' fracture; *B*, two months after periarterial sympathectomy.

tomy) (Fig. 7). We believe that the nerve fibers in the adventitia of the large arteries of the extremities have a definite trophic function and it is the interruption of abnormal trophic reflexes which course along these nerve fibers that accounts for the striking beneficial results which follow the operation of periarterial sympathectomy. These neurotrophic fibers in the adventitia of the large arteries have been shown to be segmentally distributed to this periarterial nervous network from the peripheral somatic nerves. The fact that these fibers do not course through the regional sympathetic ganglia or chains may account for the failure of improvement of post-traumatic osteoporosis after the surgical removal of the regional sympathetic ganglia (sympathectomy) or interruption of the rami to the ganglia (ramisection) while striking improvement usually follows the denudation of the major artery to the affected part. In the present state of our knowledge we do not recommend operations upon the sympathetic ganglionated cords or the blocking of the impulses through these structures by the use of novocain or alcohol in the management of post-traumatic osteoporosis.

In June, 1940, we[9] reported 34 patients who presented the signs and symptoms of the acute variety of post-traumatic osteoporosis and who were treated solely by periarterial sympathectomy. All of these patients had relief of these aching pains and edema within twenty-four hours after the operation and loss of function began to show marked improvement within a few days. These patients were able to resume their work within an average time of three months. Complete return of function in the control group treated by means of physical therapy, roentgen therapy and all other conservative means took more than nine months. Analysis of the patients in this

control group showed that the course of the disease was only slightly shortened and the unfavorable sequelae were about as frequent as when the process was left untreated.

CONCLUSIONS

1. Post-traumatic osteoporosis is a disease entity with characteristic roentgenologic changes in the three main stages of the evolution of the disease.

2. Post-traumatic osteoporosis, if left untreated, may result in ankylosis of one or more joints and give permanent disability.

3. Onset and severity of trophic changes in bones is not proportional to the intensity of the trauma.

4. Early recognition of the disease is essential to successful treatment.

5. Whenever pain persists after trauma to an extremity suspect post-traumatic osteoporosis and make roentgenograms of the affected extremity at regular intervals until the cause of pain has been established.

6. Post-traumatic osteoporosis is frequently overlooked and the complaints of the patient are frequently labeled as "compensation neurosis."

7. The period of disability has been greatly lessened by periarterial sympathectomy when performed in the acute phase of the disease.

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FURTHER LUNG-DUSTING EXPERIMENTS*

By A. E. BARCLAY, D.M., M.R.C.P., F.F.R., K. J. FRANKLIN, D.M., F.R.C.P., *and* M. M. L. PRICHARD, M.A.

From the Nuffield Institute for Medical Research

OXFORD, ENGLAND

IN THIS Institute we are especially equipped for the roentgenographic study of biological problems. While, however, the technique allows us to visualize natural processes with a minimum of operative interference, we often suffer from the fact that there is no previous experience to guide us.

Our earlier dusting experiments[1,2] provide an instance in point. In them we insufflated various radiopaque dusts into the trachea and lungs, and thereafter studied the excretion of these dusts. The only serious departures from physiological conditions were the heavy nature of the dust particles, the amounts we had to introduce, and the method of their introduction. These did not affect to any extent our study of the excretion from the respiratory tubes. What we did not realize at the time, however, was that alveoli can be (histologically) appreciably dusted without this dust being discernible in roentgenograms, even of the exsected lungs. Had we realized this, we should have confined our observations to the bronchioles and bronchi, with which we were primarily concerned, and have avoided any mention of the alveoli. As it was, we assumed an absence of dust in alveoli on the roentgenographic evidence and on the negative histological reports (owing to the nature of the experiments, exsection and fixation of the material had to be delayed until after the dusts had been excreted from the bronchioles, bronchi, and trachea, so these histological findings were no real guide to the conditions obtaining immediately after dusting).

Experiments carried out after the publication of our first series of results suggested to us that our story was incomplete, and we therefore planned a further series to ascertain the alveolar conditions obtaining immediately after acute dustings.

THE DUSTS USED

(a) *Finely Powdered Lead Glass (No. 1).* This was lead glass that we had ground down ourselves for our earlier insufflation experiments. The particles varied in size up to 45μ, the majority being from 20 to 25μ. The powder was white in color.

(b) *Finely Powdered Lead Glass (No. 3).* This was lead glass that was ground down for us through the courtesy of Parke, Davis & Co. The size of the particles tended to be less than 5μ. The powder was very slightly gray in color.

(c) *Bismuth Carbonate.* The majority of the particles varied in size from 3 to 12μ, although some were as large as 24μ. They had a tendency to agglomerate in the presence of even a small amount of moisture, so the powder was spread out thinly on paper and placed on a radiator for a considerable time before use.

(d) *Uncompressed Gas Flame Carbon.*† This was an extremely light dust, jet black in color, and therefore distinguishable, though with some difficulty, from the carbon that is ordinarily present in the lungs of many cats. The particles were very fine, some of those seen in our sections being of the order of 0.5μ in diameter.

EXPERIMENTAL TECHNIQUE

All the subjects were cats, as in our previous series. Insufflation, although suitable for the primary purpose of that series, is a very artificial method of introducing dusts into the lungs, so we also included experiments in which the subjects breathed quietly, or deeply, from a dusty atmosphere for standard periods of time.

(a) *Insufflation.* Each subject was given a small intramuscular injection of atropine sulphate to prevent excessive bronchial secretion and was thereafter anesthetized with 1:2

† This powder was suggested by Dr. H. B. Fell, who also kindly supplied the material.

* This paper is also published in *Brit. J. Radiol.*, 1940, *13*, 410–415.

chloroform-ether mixture. The rest of the procedure was similar to that in our earlier experiments, so we need only remark that the insufflations were normally effected by about 18 puffs from the insufflator, and that these puffs were given during inspiration with a short period of normal breathing between each puff.

(b) *Inhalation.* The subjects were anesthetized by intraperitoneal injections of nembutal.* When necessary, the anesthesia was deepened with a little chloroform-ether, and further injections of nembutal were given later if required. Procaine solution (2 per cent) was injected subcutaneously before the skin incisions were made. A straight glass cannula was tied into the trachea ready for connection with the dusting tube. This latter was a cardboard cylinder, with a length of 50 cm. and an internal diameter of 2.8 cm. One end was sealed off, the other was open to the air. Near the sealed end was a small hole for the insertion of the nozzle of a de Vilbiss insufflator, and a little farther from the same end, but on the opposite side of the tube, was a second hole, into which was inserted the free end of the tracheal cannula. By means of the insufflator, a heavily dusted atmosphere was created inside the cardboard tube, from which the animal had to breathe. The fact that the distal end of the tube was open to the air obviated any question of increased pressure. Precautions were taken to prevent any dust issuing from the tube from blowing back over the fur of the subject and thus confusing the roentgenographic picture.

By this technique we had short-circuited the larynx and air passages proximal to it, which presumably arrest some of the dust in inspired air. According to Tourangeau and Drinker,[7] however, human nasal filtering averages less than 30 per cent and is of little importance in preventing fine dust from reaching the lungs. A point that may be noted in passing is that the vocal cords of cats separate fairly widely even during quiet inspiration.

In earlier experiments, carried out under nembutal anesthesia, we had found carbon dioxide unsatisfactory as a deepener of respiration. We decided, therefore, to produce such deepening by direct stimulation of the larynx with a feather, passed up through the cut in the trachea. The resulting respiratory effort was intense but spasmodic in type, and can best be described as composed of deep gasps.

* Five per cent solution in distilled water; dosage 0.6 to 0.7 cc. per kg.

The total duration of the dust inhalation was in every case five minutes. Occasionally, in order to preserve quiet respiration, we made a break in the middle of the five minutes' period for the administration of a little chloroform-ether mixture.

(c) *Roentgenography.* Control lateral and posteroanterior roentgenograms of the thorax were taken before, and further roentgenograms immediately after, the dustings. The lungs and trachea were immediately exsected and roentgenographed. Additional roentgenograms were taken after fixation of the lungs and the removal of portions for histological examination in order that we might locate the exsected portions on the previous films.

(d) *Exsection of the Lungs.* We had to devise some method of killing the animals which would both obviate violent respiratory efforts and also, as far as possible, prevent collapse of the lungs on exposure. The technique finally adopted was to tighten a ligature round the trachea, simultaneously opening the thorax and dividing the phrenic nerves. The lungs, heart and trachea were then rapidly exsected *en masse*, roentgenographed, and transferred to the fixative solution (5 per cent formol saline).

(e) *Histology.* Sections were made from what was, roentgenographically, the best dusted part if the distribution through the lungs was at all uneven. The sections were examined both stained (hematoxylin-eosin) and unstained, and in some cases the use of a comparator eyepiece was found to be of value.

RESULTS

Our findings are shown in the accompanying table.

DISCUSSION OF PRESENT AND OF PREVIOUS RESULTS

(a) *Distribution of the Dusts in the Alveoli and in the Respiratory Tubes.* The number of experiments in our present series was obviously too small for the elimination of the many possible variables, so we have to proceed with some caution in drawing conclusions from the results.

Three points, however, are beyond dispute: (1) In all the subjects there was some introduced dust in the alveoli. We can therefore presume that in our earlier experiments also there was dust in the alveoli

TABLE I

RESULTS

Method	Serial No. of Subject	Dust	Deposition of Dust Gauged from:				
			Roentgenograms*				Histological Sections†
			Trachea	Bronchi	Bronchioles	Alveoli	Alveoli
Insufflation	77	Lead glass (No. 1)	+++	+++	+++	o	2
	78	Lead glass (No. 1)	++	++	++	o	2
	59	Lead glass (No. 3)	++	+++	++	o	2
	60	Lead glass (No. 3)	++	+++	+++	o	2
	79	Bismuth carbonate	++	+++	++	?+	5
	80	Bismuth carbonate	+++	+++	++	?+	4
	61	Carbon					4
	62	Carbon					2
Normal Inhalation	74	Lead glass (No. 1)	+	+	+	o	1
	75	Lead glass (No. 1)	o	o	o	o	2
	65	Lead glass (No. 3)	o	o	o	o	4
	69	Lead glass (No. 3)	o	o	o	o	1
	81	Bismuth carbonate	++	++	+	o	6
	82	Bismuth carbonate	o	+	o	o	4
	64	Carbon					4
	66	Carbon					1
	68	Carbon					3
Gasping Inhalation	73	Lead glass (No. 3 and 1)	+++	++	+++	?+	3
	76	Lead glass (No. 1)	++	++	+++	o	2
	70	Lead glass (No. 3)	o	o	o	o	3
	71	Lead glass (No. 3)	o	+	o	o	2
	72	Lead glass (No. 3)	++	++	o	o	1
	83	Bismuth carbonate	++	++	+++	+	4
	63	Carbon					6

* The symbols used have the following connotations:

o No dust present.
?+ Presence of dust possible, but far from definite.
+ Presence of a trace of dust.
++ Definite evidence of the presence of dust in a small quantity.
+++ Presence of dust in a considerable quantity.

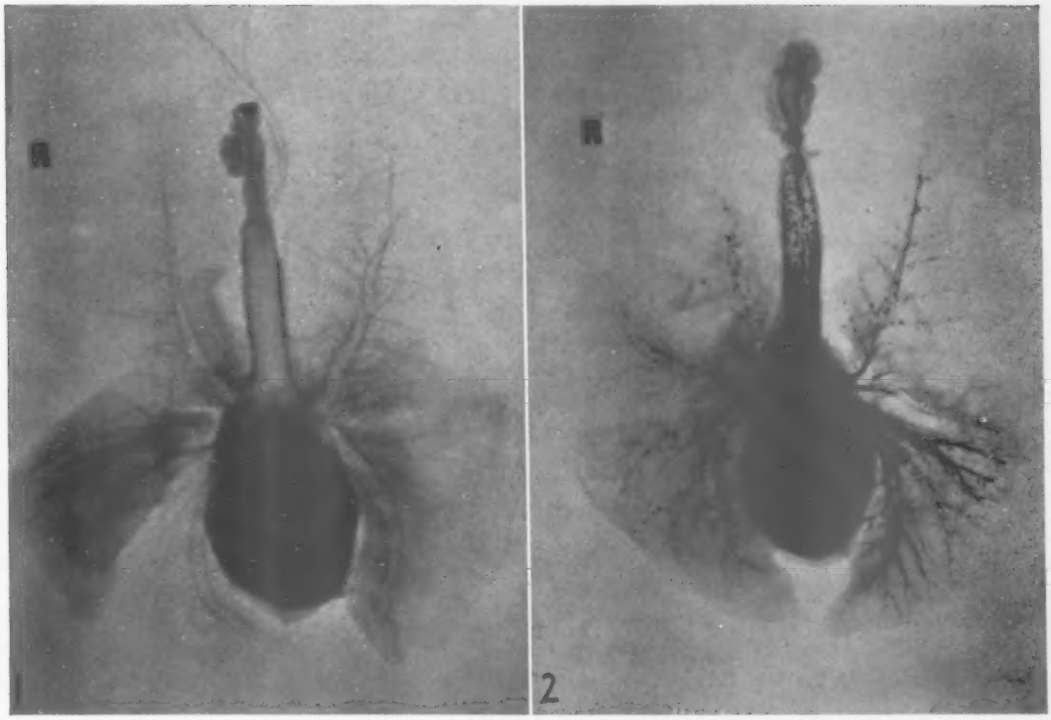
The roentgen findings are based on roentgenograms of the exsected lungs, and in most cases also on films of the lungs *in situ* before the animal was killed. The symbols were allotted all at one time, so that they should be strictly comparative.

† The numbers used have the following connotations:

1 Dust just perceptible.
2 Very small amount of dust.
3 Small amount of dust.
4 Medium amount of dust.
5 Large amount of dust.
6 Very large amount of dust.

All these numbers were allotted at one time so that they should be strictly comparative, and all reference to the experimental notes was avoided in order that there should be no bias.

immediately after the insufflations, although the necessarily delayed histological examinations gave negative results. (2) Although the amount of alveolar dusting varied much from subject to subject, it was never so great as to be detectable with certainty in the roentgenograms, even of the exsected lungs. This was in marked contrast to the obvious bronchiolar dusting. (3) The amount of alveolar dusting did not run parallel with the amount of bronchiolar dusting, as seen on histological examina-



Figs. 1 and 2. Roentgenograms of exsected material from two cats to show that the quantities of dust in the tubular systems can be vastly different, even when the same dust is introduced and the amounts found histologically in the alveoli are of the same order. In each case the histological section was taken from the middle of the left lower lobe.

Fig. 1. Subject No. 82. Dust: bismuth carbonate. Normal inhalation for five minutes. *Roentgenographic finding:* a trace of dust in bronchi, none elsewhere. *Histological finding:* a medium amount of dust in alveoli.

Fig. 2. Subject No. 80. Dust: bismuth carbonate. Insufflation. *Roentgenographic finding:* a considerable quantity of dust in trachea and bronchi, a smaller quantity in bronchioles, possibly—but not definitely—some dust in alveoli. *Histological finding:* a medium amount of dust in alveoli.

tion. This last point can be extended if the histological sections can be regarded as typical samples of the dusted portions of lung, for in that case we can amalgamate the macroscopic (roentgenographic) and the microscopic findings and say that the amount of alveolar dusting did not necessarily run parallel with the amount of bronchiolar *and bronchial* dusting. Almost identical quantities of a particular dust could be present in the alveoli of two subjects, while the bronchioles and bronchi of one were loaded and of the other practically clear (see Figs. 1 and 2). In other words, the condition of the tubular system, which can be readily assessed when radiopaque dusts are used, is no guide to the alveolar condition in any particular case.

In addition to the three definite facts that we have mentioned above, we may point out that the *averages* of the figures for the alveolar dustings in our present series are practically identical (2.9, 2.9, and 3.0 respectively) for the three different methods of introduction. We are justified in averaging the figures only if the histological sections can be taken as typical samples of the dusted portions of lung, and if the indicative numbers in Table 1 are roughly proportional to the actual amounts of dust that reached the alveoli. A much longer series of experiments would be necessary

to *prove* the suggestion, evolved from our results, that insufflation, quiet respiration, and gasping respiration allow similar penetration of dusts into alveoli. Unfortunately, one of the effects of the war has been to produce a dearth of subjects for research, so we must content ourselves with the publication of the suggestion, and leave it to be verified or not, by ourselves or by others, as future opportunities allow.

Supposing, however, that the average amount of dust entering alveoli were the same whichever of our three methods was employed for its introduction, then we should be justified in averaging the amounts found in alveoli with each particular dust. In our present series, on such analysis, we should find that the penetration of dust was lowest with powdered lead glass, intermediate with carbon, and greatest with bismuth carbonate. If we can confirm our original premise, and thereafter grade dusts in this way according to the degree of their penetration into alveoli, we may come nearer to a better understanding of the conditions governing such penetration, and this would be of value in the study of industrial pulmonary disease.

One further point needs to be mentioned and that is that introduced dusts appear to collect in relatively greater amounts in inflamed areas of lung. It is rare to find a cat's lung that is completely healthy throughout, so comparisons of normal and abnormal areas are very possible in this species, and the observation that we mention has appeared several times in the histological reports. Although the exact reason for this differential deposition of dust remains to be ascertained, the fact is perhaps worth recording in view of its possible bearing upon the problems of industrial pulmonary disease.

(b) *The Excretion of Introduced Dusts from Alveoli.* In our present experiments, as opposed to our previous ones, we obtained some evidence as to the *rate* of excretion of dusts from alveoli, for in a number of cases alveolar dust cells were found to have ingested dust particles within a matter of minutes from the penetration of these latter into alveoli. This finding is in line with those of others before us (*e.g.*, Seemann,[6] Carleton[3]), and we can well believe that the total elimination of small amounts of dust from the alveoli is a rapid process in *healthy* subjects.

Our earlier experiments also gave a suggestion as to the *route* of excretion, for we found no roentgenological evidence of any deposition of dust in the bronchial lymph nodes, although some of the subjects had received several insufflations of radiopaque dust over a total period of many weeks. We incline, therefore, to the view that, normally, the loaded alveolar dust cells move towards the ciliated epithelium of the bronchioles, are caught up on the layer of viscid mucus, and are carried up with it by the action of the cilia. The absence of accumulations of radiopaque dust in the lymph nodes seems to indicate that this route of excretion is little used in the case of healthy animals.

The main excretory mechanism thus appears to be the ingestion and carriage of dust out of the alveoli by migratory dust cells, and the subsequent upward passage of these cells by ciliary action on what Proetz[5] styled the "mucous blanket." In this way, dust penetrating into the lungs is brought back to the pharynx, whence it is swallowed and passed out by the alimentary canal, as we saw in the roentgenograms of our earlier experiments.

In striking contrast to the straightforward insufflation experiments of our earlier series were those in which the insufflated dusts were washed down into alveoli by subsequent intratracheal injections of a few cubic centimeters of fluid. In these cases not only were alveoli rendered radiopaque over large areas of lung, but in addition the excretion of the dusts from them was very considerably delayed. As the ciliated epithelium had not been damaged, the slowness of excretion must, we think, be ascribed primarily to the actual quantity of dust carried down by the fluid, and to the consequent overwhelming of the protective

dust cell mechanism, which is not adapted to meeting demands of this order.

Chronic irritation of the air passages in man leads to a replacement of the ciliated epithelium by cells of the goblet type, and in addition there is a greatly increased production of mucus by the buried glands.[4] Such pathological changes will tend to affect adversely both parts of the excretory mechanism to which we have referred, for (1) the excess fluid will tend to carry dust down into alveoli, thus throwing extra work on to the alveolar dust cells, and (2) the disappearance of the ciliated epithelium produces local impairment of the escalator mechanism by which the loaded dust cells are removed. The pathological act of coughing must be brought into play under such circumstances to clear the bronchial tree.

(c) *General Survey of Previous and Present Experimental Findings.* Looking back over our experiments as a whole, we are impressed by the extraordinary efficiency of healthy lungs in dealing with the very large quantities of dry dust that we introduced into them. This makes us suspect that preexisting disease in these structures may well interfere with the excretion of dusts and be a potent factor in the causation of industrial pulmonary complaints. Our work also strongly suggests that excessive watery secretion from the bronchiolar and bronchial glands, such as might occur under certain pathological conditions, would tend to carry dust down into the alveoli. An outstanding feature in our experiments was the apparent existence of a defense mechanism preventing the entry of large quantities of dust into alveoli, for the total amounts in them were comparatively small, even when the bronchioles were heavily loaded. We have begun work upon this problem and have already obtained results that encourage us to proceed farther; the anatomical structure of the parts is in accord with our working hypothesis. A final point of interest, to which we have not hitherto referred, is that the lungs can deal effectively with suspensions of active fungi (*Monilia*) introduced into them, for we found that swabs taken from the bifurcation of the trachea only a short time after infection were invariably sterile.

SUMMARY

We are not giving any special summary of our latest findings, as we wish rather to focus attention on the discussion of both our present and our previous results.

ACKNOWLEDGMENTS. The preparation, sectioning, and staining of the histological material was carried out mainly in the University Department of Physiology, Oxford, through the courtesy of Dr. H. M. Carleton and of Mr. E. H. Leach. A minor portion of the sectioning and staining was done in the Department of Embryology and Histology, University College, London, through the courtesy of Mr. K. C. Richardson. We wish to express our gratitude to all three histologists for the above-mentioned, very considerable assistance. To Mr. Leach, in addition, we are very greatly indebted for the comparative report on the alveolar findings in the whole series of sections.

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CONTRAST VISUALIZATION OF THE HEART AND GREAT VESSELS IN EMPHYSEMA*

By MARCY L. SUSSMAN, M.D., MORRIS F. STEINBERG, M.D., *and* ARTHUR GRISHMAN, M.D.†

From the Departments of Radiology and Electrocardiography, The Mount Sinai Hospital
NEW YORK, NEW YORK

THE rôle of emphysema and of bronchial asthma in heart disease has been the subject of considerable discussion.[1] There has been a time-honored belief, for example, that in emphysema sooner or later the heart fails. This was assumed to result from destruction and narrowing of pulmonary capillaries when the lung tissue was overdistended. However, in many cases at postmortem the heart was not enlarged and in fact often appeared smaller than normal. Furthermore, it was shown experimentally that (*a*) a very considerable amount of lung tissue had to be obstructed before there was any rise in pressure in the pulmonary artery and (*b*) no obstruction to the flow of blood through emphysematous lungs was present unless the process was far advanced.[3]

Because the symptoms and signs of extensive emphysema and early cardiac failure are the same, clinical data regarding their interrelationship is difficult to evaluate. Electrocardiograms and roentgen examinations are admittedly misleading because the heart is situated vertically and often appears small and distorted due to the low position of the diaphragm. One recognized exception is a generalized cardiac enlargement or cor pulmonale which is found occasionally.

In 1936 Kountz, Alexander and Prinzmetal,[2] reviewing 17 autopsied cases of emphysema, found evident enlargement of the heart in 10, no enlargement in 7. In the 10 cases with enlargement, a dilatation of the right ventricle was constant as well as obvious thickening of the muscle of both ventricles. Similar findings were obtained when compensatory emphysema was produced experimentally following multiple lobectomy. Out of 19 dogs the hearts appeared normal in 8. In 11, right ventricular dilatation was present along with hypertrophy of both ventricles. No satisfactory explanation was offered for the fact that right ventricular dilatation was not constant nor for the hypertrophy of the left ventricle which occurred whenever the right side was enlarged. These investigators concluded that "there is experimental evidence which indicates that the right ventricular dilatation and hypertrophy occur chiefly in the earlier stage of emphysema when the lungs are in the process of distention rather than later as generally believed." Parkinson and Hoyle[5] reported in detail the clinical and roentgen observations in 80 patients with emphysema. They concluded that 58 per cent had pulmonary heart disease. However, this diagnosis in most instances was based only upon enlargement and increased density of the hilar vessels.

TECHNIQUE

Twenty-eight patients with emphysema of various types and grades were subjected to contrast visualization of the cardiac chambers and great vessels following the injection of 70 per cent diodrast solution.‡ These patients were unselected. Most were ambulatory and currently being seen in our out-patient clinics. The technique of injection was that described by Robb and Steinberg.[6] Recording of the roentgen findings was carried out by various methods. In all cases visual observation and multiple photographs of the fluoroscopic screen were made on 35 mm. film by the fluorographic method.[9] In many cases these were supple-

‡ Kindly supplied by the Winthrop Chemical Company of New York.

* Presented at the regular meeting of the New York Roentgen Society, Nov. 18, 1940.
† Fellow of the Dazian Foundation for Medical Research.

mented by moving pictures of the fluoroscopic screen, roentgen kymograms and direct roentgenograms.

Clinical history, physical examination, posteroanterior roentgenograms, electrocardiograms, circulation studies and vital capacity were recorded in all patients.

EVALUATION OF CONTRAST ROENTGENOGRAMS

In this study particular attention was paid to the size of the right ventricle which was estimated in the left oblique view according to the following criteria:

1. The direction of the interventricular septum when the right ventricular cavity was filled with opaque material. In normal controls the septum constantly showed a convexity to the right, the convex curve extending down to and including the apex. This corresponded to the appearance of the septum in cross-sections of the normal heart[8] and in postmortem opacification of the cardiac chambers.[4] Convexity to the left was considered definite evidence of right ventricular dilatation.

2. The width of the ventricular cavity. This was estimated by comparison with normal controls. Care was exercised not to confuse the right auricle with the ventricle; occasionally the shadow of the auricle obscures or merges with that of the ventricular apex.

3. The size and shape of the apex.

4. The length of the outflow tract, extending from apex to pulmonic valve.

5. The length of the pulmonic conus judged as the ventricle contracted.

The size of the pulmonary artery and left ventricular cavity was estimated by visual inspection. Measurements were not made because the magnification factor was not constant.

RESULTS

From the point of view of the size of the right ventricle the 28 cases of emphysema could be grouped into three categories:

(1) In 12 cases the right ventricle was definitely dilated. In 10 the septum was convex to the left and the cavity was enlarged. In the other two the cavity was undoubtedly enlarged but the septum was straight.

(2) There were 12 cases in which the septal convexity was to the right but either the main cavity or the apex was considered larger than normal. These were classified as probable right ventricular dilatation. Two of the cases included in this group showed an equivocal enlargement of the ventricular cavity but there was definite dilatation of the base of the pulmonary artery.

(3) In 4 cases the right ventricle and pulmonary artery appeared entirely normal.

CORRELATION WITH ETIOLOGY

In Table 1, the cases are arranged according to their etiology. It may be significant that the 4 cases in which there was no evidence of any right ventricular dilatation

Table I

	Definite Right Ventricular Dilatation	Probable Right Ventricular Dilatation	Normal	Total
Emphysema with				
(a) Chronic bronchitis	5	4	4	13
(b) Asthma	2	6	0	8
(c) Tuberculous fibrosis	2	1	0	3
(d) Chronic fibrosis with bronchiectasis	1	1	0	2
(e) Kyphoscoliosis	2	0	0	2

Table II

	Hypertension	Previous Coronary Occlusion	Coronary Sclerosis	Unknown
Definite right ventricular dilatation. Septum to left	1	0	3	0
Probable right ventricular dilatation. Septum to right	4	2	3	0
Normal right ventricle	0	0	0	1

were in the group of chronic bronchitis. However, within this group there was no significant difference in the duration of symptoms or other clinical data. In the asthmatic group one patient aged thirty-eight showed definite right-sided enlargement; in another aged thirty there was probable enlargement. No correlation between the size of the right ventricle and the duration of symptoms was justified from this small series.

Coincidental Presence of Left Ventricular Enlargement

In Table II are listed those cases which were found to have left ventricular enlargement; It is evident that in 7 of these 14 cases the left ventricular enlargement could be explained by a definite etiological factor, namely hypertension or previous coronary occlusion. In 6 cases the presumptive diagnosis of coronary sclerosis was made. All of these patients were over fifty years of age. The electrocardiogram was normal in 5; there was slurring of the QRS complex in the sixth. The blood pressure was normal in all. In many the roentgen configuration of the heart and aorta suggested arteriosclerotic heart disease. However, considering the experimental work of Kountz, Alexander and Prinzmetal[2] referred to above in which an unexplained left ventricular enlargement occurred whenever the right ventricle was found dilated, a mechanism other than coronary sclerosis might be the cause of the left ventricular enlargement. In one case of mild but definite emphysema the right ventricle was found to be normal in size, the left ventricle large. Clinical and laboratory data gave no explanation for these findings.

In 4 cases with left ventricular dilatation the septal convexity was to the left; in 10, the septal convexity was to the right. It is suggested that enlargement of the left ventricle tends to counterbalance or overcome the convexity of the septum to the left which would occur otherwise in the presence of right ventricular dilatation.

Correlation with Electrocardiograms

In Table III, the cases are grouped according to their electrocardiographic findings. Several points are noteworthy. In all cases in which there was right axis devia-

Table III

	Definite Right Ventricular Dilatation	Probable Right Ventricular Dilatation	Normal
Interventricular block with tendency to right axis deviation (Wilson's type)	2	1	0
Right axis deviation	2	1	0
Left axis deviation	0	5	0
Normal	8	5	4

tion or interventricular block (Wilson's type), abnormalities in the right ventricle or pulmonary artery were found, usually with definite evidence of right ventricular dilatation. In the presence of left ventricular preponderance the left and right ventricles were enlarged but the evidence of right ventricular enlargement probably was less distinct because the tendency for convexity of the septum to the left was counterbalanced or overcome by the enlarged left ventricular cavity. In 4 cases both the electrocardiogram and the contrast studies failed to show any abnormality. In 2 of these the emphysema was very mild, the vital capacity being over 3,000 cc. In 2 cases there was marked emphysema of over fifteen years' duration. Both cases were on the basis of chronic bronchitis, one in addition had scoliosis. In both the vital capacity was markedly reduced. We can offer no explanation for the lack of ventricular dilatation in these two cases. In about 50 per cent of the cases in which the electrocardiogram was normal, i.e., in 8 cases, the convexity of the septum was definitely to the left indicating right ventricular dilatation. In 5 of these, the left ventricle also was enlarged which might account for the absence of preponderance of either ventricle.

The circulation times of ether and calcium gluconate were normal in all cases. The venous pressure also was uniformly normal except in one case in which there was a rise before death to 15.5 cm. of water. This case was examined postmortem and is reported in detail.

CASE REPORT

J. T. (No. 464335).

First Admission. The patient was a Polish woman, aged forty-eight, who was admitted to the service of Dr. George Baehr in 1935 at which time she complained of severe headaches, cough, expectoration and shortness of breath. In 1917 she had had influenza.

Examination revealed marked cyanosis of face, lips and fingers. The fundi revealed hyperemia of nerve heads, margins obscured, elevation 1.5 diopters. The veins were markedly distended, cyanotic and tortuous. The arteries were of good caliber. There was no evidence of sclerosis. There was marked tenderness on pressure over both antra and the left frontal sinus. The chest configuration was that of mild emphysema; mild kyphosis was present. The heart was normal to percussion and auscultation, aside from a loud second pulmonic sound. The blood pressure was 125/85. Auscultation of the lungs revealed fine to medium moist crackling râles with occasional whistles throughout. There was dullness over the left upper lobe anteriorly and posteriorly. The diaphragm moved but its excursion was limited. There was moderate clubbing of fingers.

Laboratory Data

Hemoglobin: 115 per cent (Sahli). Red blood cells, 6,500,000; white blood cells, 7,100.
Polymorphonuclear leukocytes: 64 per cent. Sedimentation time 18 mm. in twenty-five minutes.
Venous pressure: 2.5 cm. No rise on right upper quadrant pressure.
Blood Wassermann: negative.
Urea nitrogen: 7 mg. per 100 cc.
Arterial blood oxygen: 24.5 volumes per cent.
Arterial blood oxygen capacity: 27.7 volumes per cent.
Oxygen saturation: 88.4 per cent.
Vital capacity; 1,600 cc.
Saccharin time: 15 seconds.
Ether time: 7.5 seconds.
Total blood volume: 141 cc. per kilogram.
Electrocardiogram: pronounced right axis deviation; P-waves notched and prominent.
Sputum examinations were negative consistently for tubercle bacilli.
Urine showed the presence occasionally of albumin.
Lumbar puncture yielded normal fluid under normal pressure.

Roentgenogram of the chest showed fine infiltrations diffusely scattered throughout both lungs; the left lower lobe showed dense fibrosis. The heart was drawn to the left. Roentgenoscopy in all positions showed no enlargement of the heart. There was slight prominence of the pulmonic conus.

Bronchogram revealed fusiform dilatation of all the bronchi except those of the right upper lobe. There were saccular dilatations of the right lower lobe branches.

Roentgen examination of the paranasal sinuses showed clouding of the right antrum.

It was felt that this patient was suffering from emphysema, fibrosis and bronchiectasis, secondary to which she had developed poly-

FIG. 1. Male, aged sixty-seven, with chronic bronchitis and emphysema for ten years. In addition the patient had a marked hypertension. The right ventricle (*R.V.*) was dilated. The convexity of the septum was to the left. Normally the septum is convex to the right. See Figure 3. The pulmonary artery (*P.A.*) and left ventricle (*L.V.*) are enlarged.

cythemia. The headaches were ascribed to anoxemia and sinus disease.

Course. The patient was treated by sinus irrigations with little or no relief and left the hospital after two weeks. She was repeatedly seen and treated in the Out-Patient Department until her second admission.

Second Admission. In December, 1936, the patient re-entered the hospital because of chills, elevated temperature up to 103° F. and pain in the right anterior chest.

Physical examination showed no change from that of the first admission.

Laboratory Data

Hemoglobin: 108 per cent (Sahli)	Hematocrit: 61 per cent
Red blood cells: 6,000,000	Cell volume: 3,520 cc.
Sputum revealed Friedländer's bacillus on culture	Blood volume: 105 cc. per kilogram
Vital capacity: 1,400 cc.	Plasma volume: 2,250 cc.

Course. The patient was treated with oxygen for four weeks. The fever finally subsided. She had several such febrile episodes in 1937 and in 1938 for which hospitalization was required. These episodes usually lasted for from four to six weeks. Repeated studies showed no deviation from the previous status.

Last Admission. The patient was admitted for the last time in October, 1940, because of increased dyspnea, headaches and chest pain. Two days previously she had been seen in the clinic where two phlebotomies totalling 1,000 cc. were done in an attempt to relieve severe dyspnea. The hemoglobin fell from 105 per cent to 103 per cent.

Aside from increased dyspnea and orthopnea, distended peripheral veins and extremely

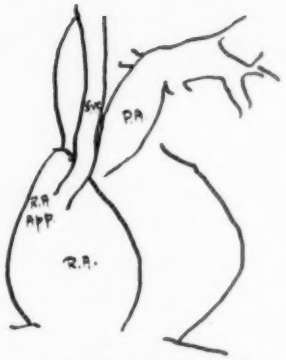


FIG. 2. When the right auricle (*R.A.*) is opacified its shadow obscures the right ventricle (*R.V.*) simulating a dilated right ventricle. Compare with Figure 3.

marked cyanosis, the physical status was unchanged. The chest appeared more markedly emphysematous than previously. The blood pressure was 134/74. The liver was palpable three fingers' breadth below the costal margin. Pitting edema of ankles was elicited.

Laboratory Data

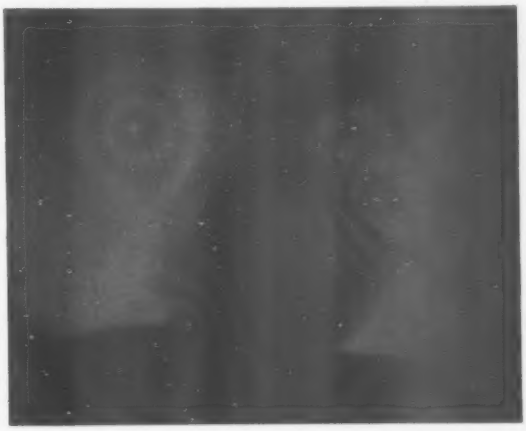
Hemoglobin: 102 per cent (Sahli). Red blood cells: 5,350, 000.

Electrocardiogram: T_2 and T_3 low; T_4 was inverted in addition to the right axis deviation previously noted.

Venous pressure: 15.5 cm.; there was a rise to 22 cm. on right upper quadrant pressure.

Saccharin time: 26 seconds.

Course. In spite of phlebotomies, mercupurin, sulfapyridine, etc., the patient's condition grew rapidly worse; the temperature rose to 106° F., she became irrational and died six days after admission.



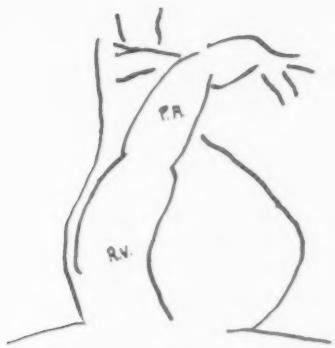


Fig. 3. Same case as Figure 2. Male, aged fifty-four, with chronic bronchitis following "gassing" in World War 1. The right ventricular cavity (*R.V.*) and pulmonary arteries (*P.A.*) are slightly dilated. The convexity of the interventricular septum is to the right.

Fig. 4. Male, aged sixty, with marked bronchitis and arteriosclerotic heart disease. Right ventricle (*R.V.*) dilated as shown by increase in its width but not in its length. The pulmonary artery (*P.A.*) shows considerable dilatation. The left ventricle (*L.V.*) was elongated and enlarged. In spite of this the interventricular septal convexity is to the left.

Necropsy Findings (*Gross*) No. 11659. Cylindrical and saccular bronchiectasis; marked acute and chronic bronchitis; confluent broncho-

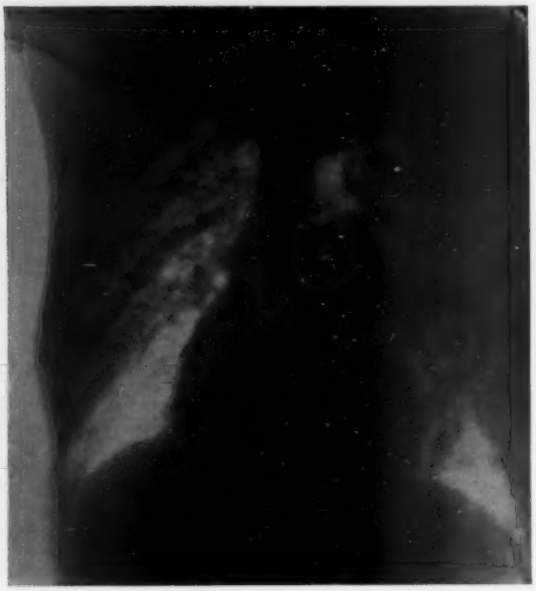


FIG. 5. Female, aged forty-eight, with chronic bronchiectases and cor pulmonale. The right ventricle (*R.V.*) is moderately dilated. The pulmonary artery (*P.A.*) is markedly dilated.

pneumonia—both upper lobes and right lower lobe; chronic pneumonia—chronic interstitial pneumonitis left lower lobe; pulmonary emphysema; pulmonary edema; marked pulmonary arteriosclerosis; bilateral fibrous pleural adhesions and pleuropericardial adhesions; calcified bronchial lymph node; striking hypertrophy of right ventricle; moderate hypertrophy of left ventricle; moderate dilatation of all chambers; acute congestion of liver.

Correlation with Heart Size. The size of the heart was estimated from the transverse diameter and the height and weight, according to the method of Ungerleider and Clark,[10] and was found to be within normal limits. There was no correlation between this measurement and the degree of right ventricular dilatation.

CONCLUSIONS

(1) Contrast visualization is an excellent method for the study of the size of the cardiac chambers in emphysema. This has already been pointed out by Robb and Steinberg[7] in their complete report on a case of emphysema in which the cardiac chambers and great vessels were visualized.

(2) Multiple exposure technique is necessary to estimate the size of the chambers which vary during the cardiac cycle. Furthermore, since the right auricle not infrequently obscures the right ventricular cavity, several records during the early part of the injection are essential.

(3) In 24 of 28 unselected cases of emphysema of various types and grades there was some evidence of right ventricular dilatation or dilatation of the base of the pulmonary artery. In 50 per cent of these, or 43 per cent of the total, dilatation of the right ventricular cavity was unequivocal and the interventricular septum was convex to the left (in normal individuals the septum is convex to the right).

(4) In this rather small series, right axis deviation or interventricular block of the type described by Wilson was constantly associated with abnormalities of the right cardiac chambers. The normal electrocar-

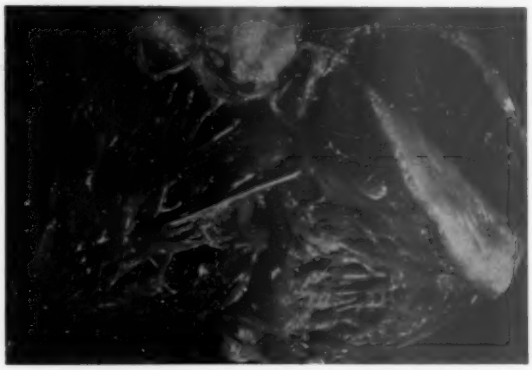


FIG. 6. Postmortem specimen of case illustrated in Figure 5. Marked dilatation of the right ventricle and of the pulmonary artery was confirmed.

TABLE IV

Patient	Serial No.	Age	Weight in pounds	Height in inches	Blood pressure	Electrocardiogram	Circulation Studies: Ether (seconds)	Circulation Studies: Calcium gluconate	Circulation Studies: Venous pressure	Vital capacity (cc.)	Heart size	Contrast Studies: Right ventricle	Contrast Studies: Pulmonary artery	Contrast Studies: Left ventricle	Contrast Studies: Aorta	Remarks
L.J.	20	60	162	65	130/80	Interventricular block (Wilson)	7	13	—	2400	+5%	Dilated; septum convex to left	+	++	+	Chronic bronchitis with marked emphysema; arteriosclerotic heart disease
S.S.	29	63	147	65	80/60 140/90	RT2 depressed; T3 inverted	—	—	—	—	+7%	Dilated; septum convex to left	+	+++	+	Dyspnea; anginal syndrome; kyphoscoliosis
J.W.	48	73	138	64	144/90	QRS slurred and notched; T4 diphasic	8.5	19	9	1800	0	Dilated; elongated conus; septum deviated to left	+	+	+++	Cough 2 years; laryngeal polyp; anginal syndrome
S.M.	50	74	126	65	128/74	Normal	6.5	17	7	1800	+10%	Dilated; septum convex to left	+	++	+	Chronic bronchitis and emphysema for many years
M.S.	58	52	148		144/104	Normal	—	17	5.5	2000	+10%	Dilated apex: septum convex left	+	Hyp	0	Dyspnea with wheezing many years; chronic bronchitis with emphysema
S.M.	59	—	134	67	146/98	Normal	5	16	4	1600	0	Septum slightly convex to left; ? dilated cavity	+	0	0	Emphysematous chest; varicosities in left bronchus giving rise to hemoptysis
A.W.	62	49	154	71	128/83	Normal	6	14	3.5	2600	−15%	Dilated; septum convex to left	+	0	0	Scoliosis; bronchial asthma
M.T.	64	58	165	66	140/84	Interventricular block (Wilson)	8	17	6.5	1900	0	Dilated especially apex; septum straight	0	+	0	Chronic bronchitis; angina pectoris
J.G.	71	67	140	61	188/102	Normal	5	15	10	2000	0	Dilated; septum convex to left	+	++	+	Chronic cough 10 years; dyspnea
S.T.	72	38	154	63	132/88	Right axis deviation	6	15	7	2700	−15%	Right ventricle dilated	+	0	0	Chronic bronchitis, several years
J.T.	44	48	130	63	115/82	Marked right axis deviation; T4 diphasic	3.5	13	14	700	0	Dilated; septum convex to left	+++	0	0	Bronchiectasis, kyphoscoliosis
E.A.	76	68	145	65	144/88	Normal	7.5	16	3?	2000	−5%	Dilated	+	0	0	Inactive tuberculosis
E.H.	12	44	150	71		Normal	—	—	—	2200		Normal	+	++	+	Asthmatic bronchitis; few symptoms, mostly neurotic
A.S.	51	50	160	63	136/94	Left axis deviation; slurred QRS	5	14	4.5	2900		Slightly dilated	0	+	0	Emphysema; chronic bronchitis, 2 years; anginal syndrome
H.P.	55	60	118	66	127/97	Normal	5	14	7.5	2200	0	Dilated; septum convex to right	0	0	0	Chronic fibroid tuberculosis, kyphoscoliosis
H.L.	57	57	165	64	138/86	Normal	6	12	7	2700	0	Large right auricle; right ventricle slightly dilated	0	+	0	Bronchitis with emphysema
A.K.	60	54	120	65	104/81	Normal	5.5	14	7.5	1600	−10%	Normal width but elongated		+	0	Chronic bronchitis since World War I
A.B.	68	66	132	62	132/82	Previous coronary artery occlusion; posterior wall	10	16	6.5	2000	+5%	Slightly dilated	+	++	0	Asthmatic bronchitis
J.K.	70	30	120	61	124/78	Marked right axis deviation; large P waves, QRS slurred and notched	—	—	—	2200	0	Slightly dilated	+	+	0	Asthmatic emphysema
F.T.	73	51	177	69	128/80	Small Q1 and R4 QRS notched, T1 low, T4 inverted	—	—	—	2500	+5%	Slightly dilated	+	++	0	Chronic bronchitis, possible coronary closure
A.S.	46	57	131	65	155/85	Right axis deviation	6	14	10	2200		Normal	+	+	+	Chronic bronchitis, 15 years; arteriosclerosis
L.W.	42	57	161	64	200/120 (1938)	Left axis deviation	6.5	17	5.5	1500	+10%	Slightly dilated	0	+	0	Hypertensive, Wassermann 4 plus
F.L.	52	61	116	58½	160/95	Normal	8?	19?	4	—	0	Slightly dilated	+	+	+	Diaphragmatic hernia, hypertension
J.T.	65	62	182	69	176/106	Left axis deviation, QRS high voltage	9	16	0	1800	+10%	Slightly dilated	0	+++	+	Bronchial asthma, possible coronary sclerosis
M.W.	43	37	153	68	125/80	Normal	7	15	5	3400	0	Normal	0	++	+	? chronic bronchitis
A.C.	66	66	145	60	118/76	QRS low and notched, RT2, RT3 depressed, T1 low	12	19	10	1000	+5%	Normal	0	0	0	Bronchitis, microcephaly (20 years)
L.N.	74	59	115	65	100/77	QRS low	9	16	9.5	1800	0	Normal	0	0	0	Cough 15 years, moderate clinical failure 5 weeks
F.D.	75	55	131	68	116/82	Normal	5.5	14	4	3000	+5%	Normal	0	0	0	Precordial pain, emphysematous chest, chronic bronchitis

diogram did not preclude the findings of right ventricular dilatation. On the contrary in eight cases, well-defined dilatation with deviation of the septum was present. The lack of right axis deviation in some of these cases might be accounted for by the coincidental presence of left ventricular enlargement.

(5) In two cases of marked emphysema with chronic bronchitis of long duration, there was no right ventricular dilatation. No explanation is offered for this finding. In two other cases in which a normal right heart was found the clinical symptoms and normal vital capacity suggested extremely mild involvement.

(6) Coincidental left ventricular dilatation could be accounted for in many instances by essential hypertension or previous coronary thrombosis. In the remaining cases coronary sclerosis seemed to be the most likely explanation.

(7) In the presence of right ventricular dilatation there was also an abnormality in the movement of the interventricular septum. Analysis of this phenomenon has not been carried out sufficiently at this time to permit its presentation.

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ROENTGENOGRAPHY WITH THE AID OF A CHART MARKED OFF IN SQUARES IN THE MEASUREMENT OF THE CARDIOVASCULAR SYSTEM*

By DR. EDUARDO COTRIM
Assistant in Radiology of the Faculty of Medicine, University of São Paulo
SÃO PAULO, BRAZIL

HAVING to settle the problem of measurement of the cardiovascular system without the necessity of correcting the error due to magnification caused by central projection, we present for the consideration of roentgenologists a new process which we have named roentgenometry.

Just as graphs and designs made on paper marked off in squares shorten the work of measurement, the images obtained on films marked off in squares also have the same advantage.

It would be necessary for manufacturers to furnish roentgen films already marked off in squares, as they do for certain electrocardiographic films. This would be a great step in settling the problem of measurement but it would not be the complete solution.

It is necessary to impress on the plate a measuring chart marked off in squares, which has the same magnification as the image of the object to be measured, in order for this method of reading to be applied directly. This is accomplished by making a second exposure on an opaque grid with transparent grooves so as to form a chessboard in square centimeters and provided with a millimeter scale, which is placed at the same distance as the object projected on the roentgen film.

The roentgenogram obtained in this way presents the image of the body to be measured and a series of fine lines forming squares. As the increase in the projection of the object is the same as in that of the grid the squares serve as a means of measurement, and to make the measurement it is only necessary to determine the distance between any two points on the object by means of the superimposed squares.

The measurement will be absolutely accurate.

DISCUSSION

Various methods have been used for the study and measurement of the cardiovascular system.

Figure 1*A* is a sketch of a roentgenoscopic image which shows clearly that this process should not be used to obtain data

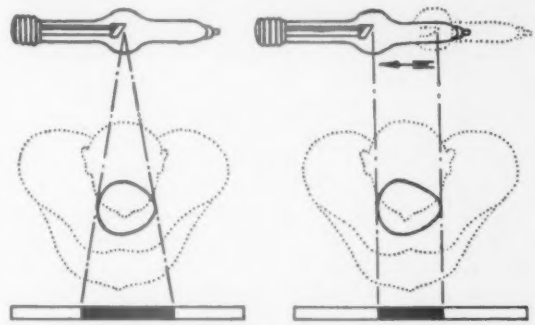

FIG. 1. *A*, diagram of roentgenoscopy; *B*, diagram of orthodiagraphy.

of measurement. Figure 1*B* shows orthodiagraphy, which consists in irradiating a large series of points on the periphery of the object, and obtaining an image in orthogonal projection by uniting all these points. In Figure 2 we have a sketch of teleroentgenography in which it is seen that even with the tube at a great distance a magnification persists, and measurements made under these conditions present an error, which is the error of magnification of the image obtained by divergent radiation. Calculations show that an image obtained with a distance of 3 meters between the focus and the plate presents an error of 3.3 per cent, that is to say, that for a strictly correct estimation it would be necessary to

* Translated by Audrey G. Morgan, M.D.

apply this coefficient of correction to all the measurements.

Now this method of procedure would make the measurements extremely slow, in addition to the work of calculation which it would involve.

With the object of obtaining direct measurements on the roentgen film without the

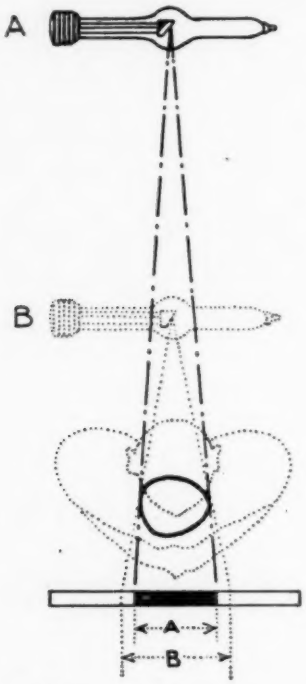

Fig. 2. Diagram of teleroentgenography.

necessity of correcting for magnification of the images, we have devised[1] and put into practice the technique of marking the roentgenograms off in squares with the same magnification as that of the images, the sketch of which is shown in Figure 3. We see here a roentgenogram of the heart taken at a short distance. Above the plane of the film the image of the heart is represented, projected by the conical bundle of roentgen rays. If in the corresponding plane, at the points farthest from the midline, we place an opaque grid with a series of fine grooves, dividing it off into squares measured accurately in centimeters, the roentgen rays, passing through these grooves will reach the plane of the film with the same primary orientation, and will impress on it the projection of these grooves. This projection will represent an area marked off in squares with the same magnification as the image of the heart; now as the squares of the grid measure exactly 1 sq. cm. it will follow that measurements made directly on the film, taking the distance between the grooves as 1 cm. in length and the area of each square as 1 sq. cm., will be absolutely accurate.

The lines which form the squares will serve as a scale for measuring the image of the heart and the great vessels.

TECHNIQUE

To make these roentgenograms marked off in squares we have constructed an apparatus made up of a grid, as described above, and two supports with which this grid is fixed in front of the roentgenographic film holder.

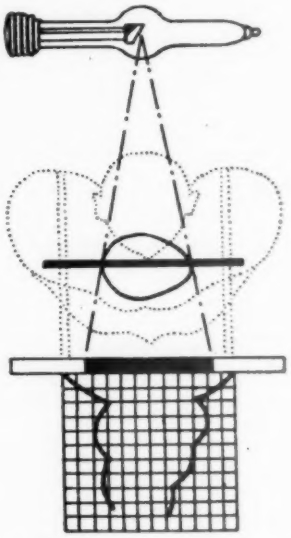

Fig. 3. Diagram of roentgenometry.

Having taken the roentgenogram of the cardiovascular system with the usual technique, or preferably decreasing the focus-film distance to 1 meter or 1.20 meter, to reduce the exposure time, thus increasing the sharpness of the heart outline, the

patient is removed and the apparatus fixed without changing the position of the film holder or the tube.

The distance of the grid from the plane of the plate is determined as follows: We know from studies made by Albers-Schönberg that the broadest part of the heart is located in a plane corresponding to one-

Fig. 4. Roentgenogram marked off in squares for measurement of the aorta in the right anterior oblique position.

third of the anteroposterior diameter of the thorax at the level of the base of the heart. If we take this distance and divide it by three we have the distance at which the grid should be located.

By means of a second exposure we project the grid on the film, using for this purpose as small an amount of rays as possible, in order to avoid secondary radiation passing through the narrow grooves and reaching the film, which would cause a great deal of magnification and as a result would make the image of the grooves in the measuring chart very broad.

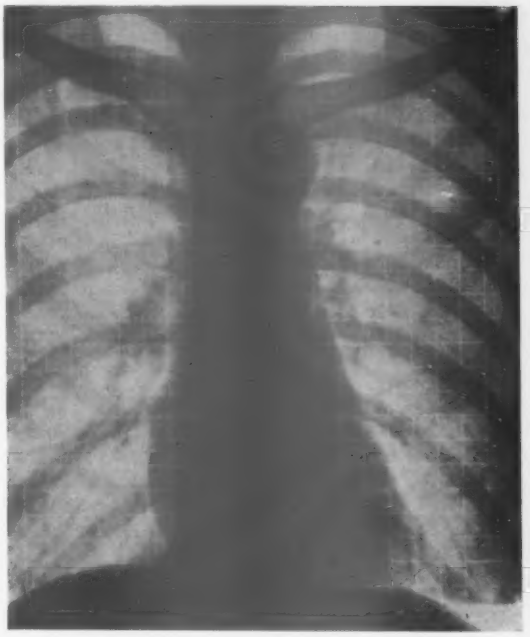

Fig. 5. Roentgenogram marked off in squares of the thorax in the frontal position.

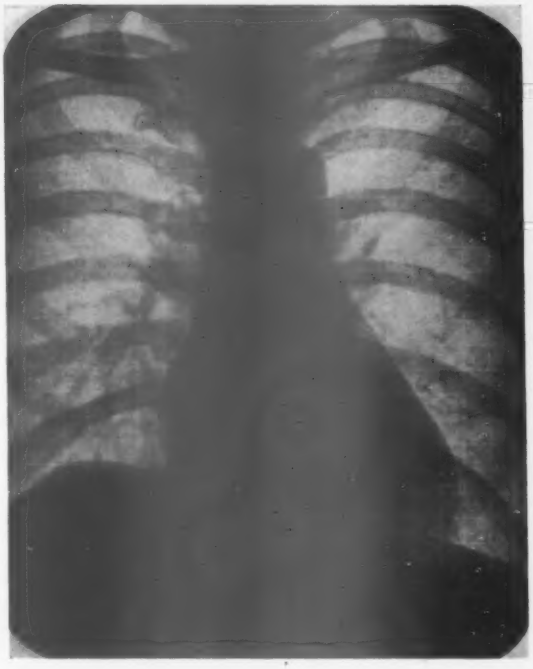

Fig. 6. Roentgenogram marked off in squares in the frontal position, showing the diameters of the heart.

We have shown in another work[2] that in spite of the fact that this placing of the grid would seem to be a great cause of error, nevertheless roentgenometry is one of the most accurate, if not the most accurate, of the methods of measuring the cardiovascular system.

ADVANTAGES

Among the various advantages of our method is its simplicity, as it merely requires a second exposure on the grid.

Direct measurement on the film, in addition to avoiding the calculation for correction of the magnification of the image, allows of measurements being made at any time, and makes it possible to revise case histories in order to establish statistics for a given measurement.

As the roentgenograms carry the impression of the measuring chart with which they are measured they constitute impersonal documents which can be evaluated even by those who are not roentgenologists and who do not know the error due to magnification of the image.

The superposition of the tracing of the measuring chart does not interfere in the least with the sharpness of the images, as can be seen in Figures 4, 5 and 6; it constitutes a standard by which any measurements can be made by any process.

The decrease of the distance in roentgenograms of the cardiovascular system makes it possible to obtain very clear images of the outlines of the heart, even in cases of tachycardia. By using short distances very clear roentgenograms may be obtained of the chest wall by means of which the measurement of the anteroposterior diameter which is used in determining the volume of the heart can be made.

CONCLUSIONS

(1) A new method of measuring the cardiovascular system directly on the roentgen film is presented.

(2) This method consists in obtaining roentgenograms marked off in squares and provided with a millimeter scale.

(3) The grid marked off in squares is placed at the same distance as the organ to be measured and, by means of a second exposure, is projected on the roentgen film with the same magnification as that of the organ.

(4) As the increases are equal, the measuring chart is a scale and the measurements may be made directly.

(5) By decreasing the distance from tube to film, better roentgenograms of the outline of the thorax can be made which serve for the measurement of the depth of the heart, used in determining the volume of the heart.

(6) The roentgenogram marked off in squares is an impersonal document which can be examined by any specialist without knowing the coefficient of error due to the distance at which the roentgenogram was made.

(7) In examining records the roentgenogram marked off in squares can be measured at any time to establish statistics in regard to diameters, because it retains permanently the scale by which the measurements are to be made.

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THE ROENTGEN FINDINGS IN INCREASED LEAD ABSORPTION DUE TO RETAINED PROJECTILES*

By HYMAN R. SENTURIA, A.B., M.D.
ST. LOUIS, MISSOURI

THE fact that absorption of lead from retained projectiles can occur in sufficiently large quantities over a period of years to result in chronic lead poisoning is definitely established by the isolated cases which have appeared in the literature from time to time. The mechanism of and the predisposing factors necessary for this development are not very clearly understood. In view of the relatively few cases of this condition reported in the literature thus far, there would seem to be a marked discrepancy between the number of gunshot wounds seen in an active roentgenological service, and the very occasional reported case of poisoning as a result of absorption from the retained bullet.

Although very little attention is given in the English literature to the subject of chronic lead poisoning as a result of projectiles retained in the body over a period of years, a number of references to this condition are to be found in the foreign literature. Küster and Lewin[8] in 1892 collected and reviewed the cases which had been reported up to that time and selected 5 cases which they felt were unquestionably instances of lead poisoning. Included among these are the cases of Pluskal,[14] Bronvin,[2] and Naunyn.[11] They report their own case, that of an army officer who was shot in the right knee. The wound of entry healed uneventfully and the bullet was not searched for. He began to complain of abdominal colic and loss of weight seventeen years after the injury. Examination showed a lead line on the gums, moderate anemia, pallor, and a slight tremor. Chemical analyses of the urine showed evidence of lead excretion. The patient was operated upon and the bullet path was found to have penetrated the head of the right tibia. The bone and periosteum in the vicinity of the bullet path was found to be infiltrated with numerous small flat dust-like particles of lead. The track of the missile was chiselled out and the patient made a gradual and uneventful recovery.

The first reference to the roentgen findings is made in an article by Nimier and Laval[13] in 1901 who reported the case of an officer who sustained a charge of No. 9 buckshot in the palm of the left hand. After only four weeks there were complaints of abdominal colic, and a definite lead line was demonstrated. The roentgen examination showed lead infiltration of the palmar aponeurosis and the deeper tissues. The patient showed a progressive improvement after removal of the shot.

In a review of the literature only 6 cases were found in which the roentgenograms were reproduced in the original articles and were available for study. These cases are reported in some detail. In addition, 2 cases which have recently come under our observation are added to those already recorded in the literature. Recently Key[6] has reported a case, the roentgenograms of which show the findings which are being emphasized in this paper, although this patient was not investigated from the standpoint of possible increased lead absorption. The roentgen findings in this case will be discussed in more detail later.

In a report by Wieting and Effendi[18] in 1910 there are included roentgenograms which show the typical findings characteristic of all the cases included in this paper. They report 2 cases in which lead projectiles have been retained in the body over a period of many years. The first case, a man, aged sixty, had been shot many years previously in the hand and now shows a stiffened wrist. A dense firm thickening is

* From the Department of Radiology of the Cincinnati General Hospital and the University of Cincinnati College of Medicine.

visible and palpable on the ulnar side of the wrist. The roentgenogram shows the bullet rather indistinctly demarcated, lying on the volar side of the lower destroyed end of the ulna and surrounded by dense black shadows. The circular form of the shadow is suggestive of a cystic encapsulation. From the main mass there are dark extensions going occasionally proximally but preponderately distally. The shadows situated in the palm of the hand probably correspond to deposits partly in the joints at the bases of the metacarpals, partly in the subfascial tissue of the palmar cavity of the hand. There are shadows radiating to the little finger which are to be considered as impregnations of the flexor tendons of the little finger.

The second case reported by Wieting and Effendi is that of a man who carried a revolver bullet in the popliteal space for an indefinite number of years. He complained only of minor pains with disturbance of motion. The roentgenogram in this case showed the completely intact lead bullet located in the popliteal space apparently directly adjacent to or in the joint capsule. The capsule was diffusely infiltrated in its entirety with lead salts including the synovial membrane and the upper surface of the joint cartilage. Both of these patients refused operation in spite of considerable persuasion and neither came to autopsy. The authors conclude, however, that these roentgen findings were positive evidence of lead absorption and that should such absorption take place over a long period of time, severe chronic lead poisoning can result. They advocated the removal of the bullet in view of the roentgen evidence of lead absorption and cautioned against the possible danger of lead poisoning.

Habs,[4] in 1927, reviewed the literature covering this subject and added 2 cases of his own, one of which showed the typical roentgen findings. This case sustained a bullet wound of the pelvis in September, 1914. The wound healed without complications and the bullet was not removed. In 1920 he began to complain of pain in the region of the right pelvis with gradually increasing limitation of motion of the right hip joint. In 1924, ten years after the original injury, he complained of abdominal colic, which at first lasted only one week then recurred every five months, the last attack occurring in February, 1926. Early in 1926 there were beginning manifestations of paralysis of both bones of the forearm and hands. The diagnosis of lead poisoning was made by a neurologist and the patient was admitted to the hospital for operation. Examination on admission to the hospital showed a chronically ill appearing male in a generally reduced condition. The skin and mucous membranes showed a moderate pallor. The gums showed a definite lead line. There was a bilateral radial paralysis somewhat more marked on the left. On both sides the extensor digitorum, the external carpi ulnaris, the external and abductor pollicis were completely paralyzed. The external carpi radialis was slightly paretic. The right hip joint showed limitation of motion in all directions and was somewhat painful on pressure. Numerous basophile granulations were found in the blood. The stereoroentgenogram showed that the missile lay in the head of the right femur, anteriorly, at the junction of the cartilage and the bone, and was surrounded by a heavy callus growth. The region of the capsule showed cloudlike shadows which were considered as lead deposits. At operation the joint capsule was exposed and was found to be distended in some places by a joint effusion and appeared slate gray in color. As much of the anterior part of the joint capsule was removed as possible. The interior of the joint capsule and the articular cartilage was everywhere smooth and glistening. The cartilage in certain spots was discolored a grayish black. On the bones, near the junction of the cartilage and the bones there were numerous periosteal overgrowths which were chiselled off. The markedly deformed missile lay solidly wedged in an irregularly formed cavity which communicated with the joint interior. The site of the missile was discolored a deep black. The patient made an uneventful recovery and there was considerable return of motion to the hip joint.

This represents a case of undoubted clinical lead poisoning which developed about twelve years after the initial injury at which time the bullet lodged in the head of the right femur. Subsequent roentgenograms and operation showed saturation of the surrounding tissues with lead which had undergone disintegration and diffusion.

Taltavull[16] in 1931 reported a case of chronic lead poisoning resulting from a bullet wound in a single Bolivian pharmacy student, aged twenty-one. He had been accidentally shot by a revolver in the left groin at the age of seventeen years. His illness began with severe constipation, weight loss, anorexia, nausea, and diffuse abdominal cramps. On physical examination there was diminution in the strength of the fingers, with marked tremor of both hands. The posterior region of the forearms was somewhat atrophied. Laboratory studies showed the presence of lead in small quantities in the urine, and basophilic stippling of the red blood cells. The roentgenograms showed a bullet adjacent to the greater trochanter of the femur with infiltration of the lead extending for a distance of about 8 to 10 cm. (Fig. 1). The patient was operated upon in April, 1931, with incomplete removal of the fragment. At the time of operation there was gray discoloration of all the surrounding tissues. At operation wide removal of all the diffusely lead saturated tissues was done but subsequent roentgenograms showed residual lead which necessitated a second operation. The patient made an uneventful recovery.

In this case symptoms of clinical lead poison-

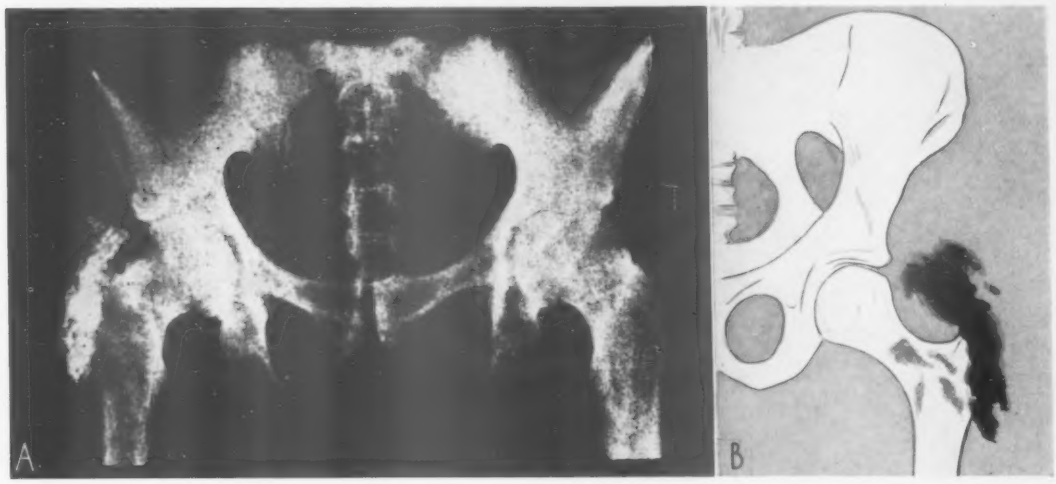

FIG. 1. Reproduction of original roentgenogram from paper by Taltavull[16] and semidiagrammatic drawing to show the extent of the lead diffusion and infiltration in the region of the left hip. (Reproduced by permission of the author.)

ing supervened nine years after the original wound. The roentgenogram showed no involvement of the head of the femur or the hip joint, but the disintegrated lead particles were present in the soft tissues adjacent to the greater tuberosity. Operative removal resulted in complete recovery.

Londres[10] in 1934 reported the case of a farmer boy aged twenty, who was wounded by a pistol shot in the left knee in 1931. He refused operative removal of the bullet and continued to work after the wound healed. Two months later he complained of severe abdominal colic. The colic was at first very severe, intermittent and recurring after an interval of several weeks. One year after the injury, he was admitted to the hospital with a bilateral radial paralysis, lead line, and a subicteric tint to the skin. Careful thorough questioning revealed no other possible source of lead which might have caused the poisoning. Roentgenograms showed the bullet embedded superficially in the tuberosity of the tibia. There were irregular spotty and streaked shadows of metallic density in the region of the joint capsule and extending along the muscle and fascial planes. At operation the bullet was found buried in a small cavity in the head of the tibia which communicated with the joint cavity. The surrounding tissues were discolored gray and infiltrated with metallic particles. Spectroscopic analysis of the tissues revealed the presence of lead in large quantities. After operation the anemia and paralysis receded and the patient was able to return to work after several weeks.

A case of clinical lead poisoning manifested by bilateral radial paralysis, abdominal colic, anemia, and lead line on the gums, which had its onset about one year following the bullet wound. Roentgenograms showed very extensive saturation and dissemination of lead in the knee joint space and along the muscle and fascial planes. Operation confirmed the roentgen findings and rapid recovery followed removal of the bullet.

In 1936 Haenisch[5] reported in great detail the case of a man, aged forty, who was referred in 1912 for a roentgen examination of the spine for the purpose of determining the location of a pistol ball which had been lodged in the spine, apparently after a duel. The view of the lumbar vertebrae in the sagittal plane showed a somewhat deformed shot at the level of the intervertebral space between the third and fourth lumbar vertebrae. Stereoroentgenograms showed that the pistol bullet lay in the region of the inferior articular process of the third lumbar vertebra. Tiny metallic particles showed that the bullet had penetrated the articular process and had been embedded at the base of the spinous process. After healing of the wound of entry, no cause presented itself for removal of the bullet. The patient was for many years completely free of symptoms until the summer of 1934 when he noticed a mild disturbance of his general well-being and complained of fatigue and loss of appetite. These were followed by complaints of bone pain of a very diffuse nature, root symptoms of the right third lumbar segment and fleeting phenomena of meningismus. The blood studies showed no changes in the red blood cells except for a striking polychromasia and anisocytosis which persisted throughout the period of observation. Roentgenograms of the spine taken at this time showed a striking change in the region of the bullet shadow. The somewhat deformed shot was still to be seen in the

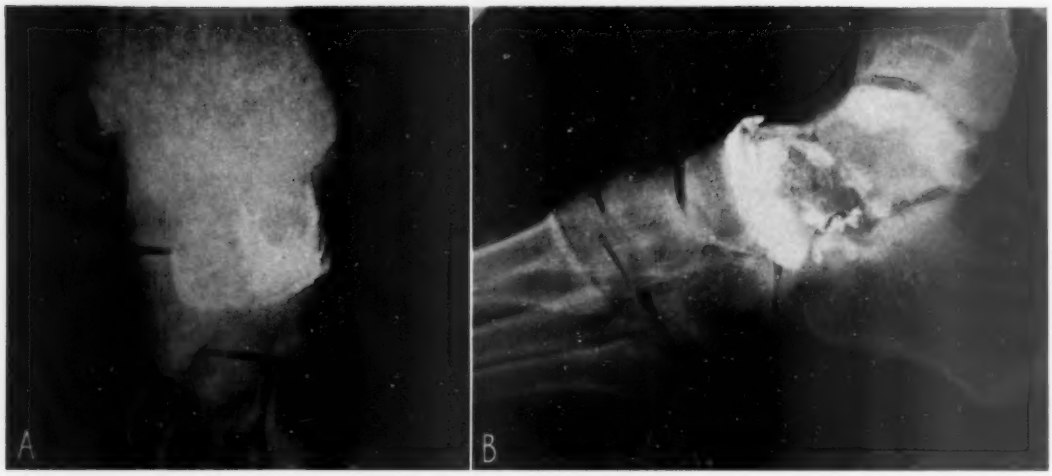

Fig. 2. Roentgenograms showing the lead in the astragaloscaphoid joint with diffusion of the metallic particles throughout the adjacent tissues. Secondary arthritic changes are present in this joint. (Roentgenograms reproduced through the kindness of Dr. Key.)

same location. The striking change consisted in the loss of the sharp demarcation of the metallic foreign body. The edges of the pistol ball fragments were hazily outlined and there was a surrounding irregularly shaded zone in which was to be found cloudy deposits of the density of metal. This zone was very sharply demarcated inferiorly as though it were encapsulated. This cloudy zone of varying shades of metallic density was considered as a lead diffusion. At operation this sac-like encapsulated zone was found to be full of gray "Bleigeschmier." All the surrounding tissues appeared discolored gray to whitish. The visibly discolored tissues were removed and the operative wound healed without complication. In the course of the next few months there were increasing manifestations of lead absorption—characterized by weight loss, abdominal colic, severe joint pains in all the extremities, meningismus, and psychic disturbances. Death resulted following a rather sudden attack of loss of consciousness with severe meningitic symptoms. There were no laboratory data to establish increased lead absorption but spectroscopic examination of the removed tissues showed large amounts of lead.

This case is of special interest for several reasons. It represents the longest interval between the initial injury and the onset of symptoms, namely twenty-two years. Roentgenograms taken at the time of the initial injury are available for comparison and show the striking changes which take place in the retained projectile. It is the only case in the series in which the outcome was fatal—apparently due to lead encephalopathy. Whether the location in the spine adjacent to the neural canal may have been a contributing factor is purely speculative.

The case reported by Key[6] is that of a male, aged twenty-two, who had received a bullet wound in the left foot from a .22 caliber rifle about four years previously. The bullet apparently was lodged in the head of the astragulus and the wound healed without complications. Roentgenograms made at the time of observation showed a large amount of opaque substance, apparently lead, in the astragoloscaphoid joint with marked narrowing of this joint space. The opaque material outlined the synovial surface of the joint and infiltrated the surrounding region (Fig. 2). At operation the tissues were found to be stained with fine grayish-black lead particles. No studies of the lead concentration in the blood and urine of this patient were made and apparently there were no clinical symptoms to suggest the presence of marked lead absorption.

REPORT OF CASES

Case 1. The first case of this type which came under our observation was C. B., male, Negro, aged forty-nine, admitted to the Surgical Clinic of the Cincinnati General Hospital on August 4, 1939, with the history of having been shot in the right wrist on July 4, 1934. The examination in the Out Patient Department showed a markedly swollen forearm. Palsy of the fingers was present, being most marked in the middle and ring fingers, together with some atrophy of the hand and forearm muscles. The roentgenogram in 1934 showed an irregular fragmented bullet mass at the inferior radio-ulnar articulation of the right forearm (Fig. 3). After recovery from

the gunshot wound he did his usual work as a hod-carrier without any difficulty. In 1937 the patient noticed that he was nervous and that his hands were shaking to the point that he could no longer hold a cup or glass to his mouth. About five months before admission to the hospital he began to have pain in his right wrist which had become progressively worse, the pain being aggravated by exercise. There was a strong alcoholic history until two or three years before admission. There was a positive history of gonorrhea and a primary penile lesion of lues. He had had between 30 and 40 hip injections of bismuth. The remainder of the history by systems is non-contributory.

Physical examination on admission showed a temperature of 98°F., respiration 20, pulse 60, blood pressure 190/70. The patient was an obese male negro, who appeared to be ill at ease, with marked tremor of the hands, more so on the right. The pupils were slightly irregular and reacted poorly to light. The few remaining teeth were markedly carious and the gums were spongy, inflamed, and showed a faint suggestion of a bluish-black line at their free margin. No glandular adenopathy. Lungs clear to percussion and auscultation. There was a systolic and diastolic murmur at the apex with a diastolic murmur at the aortic region of high pitched quality and of long duration. Abdomen negative. Prostate quite hard but not stony hard. Neurological: Marked coarse tremor of both hands with suggestion of pill-rolling activity. Weakness of the right arm due to bullet wound. Sensory examination negative. Cranial nerve examination showed evidence of third nerve involvement. Remaining cranial nerves were negative. Deep and superficial reflexes physiologically hypoactive.

Laboratory data: Urine negative. Blood: hemoglobin 90 per cent; no evidence of stippling of the red blood cells.

The following studies of the lead content of the blood and urine were made on August 17, 1939:

Urine	Volume 68 cc.	
	0.07 mg. lead per liter	
Blood	Spectrographic	Dithizone
Grams blood	12.1	10.5
Milligrams per 100 gm.	0.065	0.075

Fig. 3. Case 1. Roentgenograms made at the time of the initial injury in July, 1934, showing the irregular fragmented bullet mass at the inferior radio-ulnar articulation. The bullet though fragmented shows sharp demarcation of the various particles.

Roentgenograms made at this time showed diffusion of the lead into the adjacent soft tissues. The lead appeared to present a convex upper border suggesting an encapsulation (Fig. 4).

The patient left the hospital and was advised to return to the Medical Clinic for further study. He failed to keep his appointments and did not present himself to the Medical clinic until April 9, 1940, complaining of increasing headache and aggravation of the previously described symptoms. The gums now showed a gray line at their free margins. He was referred to the Neurosyphilis Clinic on April 18, 1940. Examination here showed that the pupils were fixed to light. The optic discs showed bilateral mild optic atrophy. There was a parkinsonian tremor of the hands. Deep reflexes obtained only upon re-enforcement. Ophthalmologic consultation showed primary optic atrophy right eye, early arteriosclerotic retinopathy. Spinal fluid showed an initial pressure of 200 mm. of water and a final pressure of 150 mm. of water. The Pandy test was three plus and the protein was 55 mg. per 100 cc. Wassermann reaction three plus, gold curve 0-0. The patient was referred to the Health Center for treatment of his central nervous system lues, but he remained uncooperative and no further follow-up was available.

FIG. 4. Case 1. Roentgenograms made in 1939, five years after the original injury, showing the extensive diffusion of the lead particles throughout the adjacent tissues. The suggestion of encapsulation is seen on the ulnar side, dorsally and proximally, where the lead particles present a sharp convex border.

This patient, after an interval of five years had elapsed between the initial wound and the onset of symptoms, showed changes in the retained projectile which could be demonstrated roentgenographically. The definite evidence of central nervous system lues complicates the clinical picture but the lead determinations were suggestive of increased lead absorption. Lack of cooperation resulted in incomplete studies.

The second case which came under our observation fortunately permitted us to

carry out full chemical and spectroscopic analyses for lead.

Case II. The patient, L. C., a white male, aged twenty-nine, was shot in the right hip in 1932 by a pistol bullet and was confined to bed for about eight weeks, following which he required crutches for a period of six to eight weeks. There was no hospitalization at the time of the initial injury and no attempt was made to remove the bullet. In 1934 the patient was referred to the roentgen department where roentgenograms of the right hip were made. These showed the major portion of the body of the bullet buried in the head of the femur with a few metallic fragments scattered in the adjacent bone (Fig. 5). He was not seen again until August, 1939, when he returned on crutches complaining of a painful right hip and limitation of motion. There had been occasional attacks of dizziness and headache during the past seven years, increasing in frequency and severity up to the time of operation. In the past two or three months he had rather marked vertigo, but no chills, fever, colic, metallic taste in the mouth, constipation, or paralysis. The industrial history included brickwork, coal mining, linoleum warehouse work. No history of exposure to lead. Family history essentially negative. Review of systems non-contributory.

Fig. 5. Case II. Roentgenogram made in 1934 showing the major portion of the bullet mass buried in the head of the right femur. The track of the bullet is shown by metallic fragments in the inner side of the neck of the femur.

Fig. 6. Case II. Roentgenogram made in 1939, five years after the original injury showing the solution of lead within the hip joint outlining the capsule of the hip joint. The main mass of the bullet is still seen but somewhat less sharply demarcated. Secondary arthritic changes are present in the hip joint.

Physical examination on admission showed temperature 98.2° F., pulse 20, respirations 26, blood pressure 164/88, poorly nourished, well developed white male who walks with the aid of crutches. Eyes: right pupil slightly irregular. Extra-ocular movement and corneal reflexes normal. Mouth: mucous membrane good color. Teeth in extremely poor condition. There is tenderness and redness of the mucous membrane over the left upper cuspid area, the result of extension of alveolar abscess and periostitis. Throat: both anterior pillars reddened. Tonsils dusky, edematous and enlarged. Chest, heart, and abdomen negative.

Laboratory data: hemoglobin 91 per cent, red blood cells 4,470,000, white blood cells 12,500, with polymorphonuclears 56 per cent, lymphocytes 21 per cent, eosinophiles 9 per cent, mononuclears 8 per cent, stippling 5/50 per high power field.

Roentgenograms made on admission showed a very striking appearance. The largest frag-

ment of the bullet was still seen buried in the head of the femur. The joint capsule was now outlined accurately by the lead which had gone into solution from the main mass of the bullet. The roentgenogram closely simulated the appearance one would anticipate after an arthrogram made with radiopaque contrast medium. The festooned appearance of the joint capsule

TABLE I

URINE AND BLOOD ANALYSES FOR LEAD CONTENT

Date	Urine (mg. per liter)	Blood	
		Spectroscopic (mg. per 100 gm.)	Dithizone
7/31/39	Vol. 70 cc.		Grams 15.7
	0.20		0.09
8/ 1/39	Vol. 1560 cc.		
	0.08		
8/ 3/39	Vol. 1000 cc.		
	0.13		
8/ 5/39 (postoperative)	Vol. 1000 cc.		
	0.13		
8/17/39	0.07	0.065	0.075
8/22/39	0.08 plus		
9/26/39	0.045	0.07	0.065
9/28/39	0.045	Grams 11.2	Grams 10.3
		0.07	0.065
10/24/40	Vol. 100 cc.	Grams 12.3	Grams 10.3
	0.065	0.05	0.075

Normal values:
Lead in blood...0.01 to 0.06 mg. per 100 gm. of whole blood.
Lead in urine....0.030 mg. per liter.
Mean concentration of lead in a liter of normal urine 0.034 mg. per liter.
Mean concentration in 100 gm. normal whole blood 0.025 per 100 gm.

and its point of attachment to the neck of the femur was well shown. There were secondary arthritic changes in the hip joint (Fig. 6).

On August 1, 1939, an arthroplasty was performed. The capsule of the joint was seen to be stained gray to black in certain areas. When the capsule was opened, numerous villous-like appendages were found within the joint space arising from the joint capsules. A portion of the joint capsule was removed and submitted for lead analysis. The articular cartilage of the femoral head was smooth everywhere except at a point about 1.5 cm. in diameter where the major portion of the body of the bullet was found to be buried. This was removed and was submitted for chemical analysis. A vitalium cap was placed over the head of the femur and the head was then replaced in the acetabulum. The wound was closed without drainage. The patient made an uneventful recovery. After two months in bed with traction, the patient was gotten up on crutches with partial weight bearing. He volunteered the information that he felt better generally then he had at any time in the past several years.

The analysis of the portion of the joint capsule showed the following:

Weight	0.76 gm.
Milligrams of lead	25.0
Milligrams of lead per 100 gm.	3300–over 3%

Analysis of the bullet removed at operation showed:

Antimony	0.17%
Bismuth	0.01%
Lead	99 plus %

The following chemical and spectrographic examinations were made* (Table 1).

When these data are represented in graphic form (Fig. 7), it is noted that there is a progressive drop in the lead concentration in both the urine and blood. This drop is rather marked in the period immediately postoperative.

DISCUSSION

From a critical study of those reported cases in which roentgenograms are reproduced, it is apparent that certain changes occur in the roentgen appearance of the retained missile which would indicate that absorption can occur and poisoning may supervene. From this standpoint, the roentgen examination may be of both diagnostic and prognostic value. Briefly, these findings consist in a definite change in the missile itself, in that there is fragmentation, disintegration, and apparent infiltration throughout the adjacent tissues. Whereas the bullet originally is well defined and sharply delimited, the changes which occur result in a diffuse disintegration of the main body of the missile into numerous smaller particles, or into a homogeneous metallic diffusion which may be rather sharply encapsulated from the surrounding tissues, or

* All chemical and spectrographic analyses of blood and urine were made by the Kettering Laboratory of Applied Physiology of the University of Cincinnati.

more likely infiltrates the surrounding tissues along the muscle, tendon, and fascial planes. The roentgen demonstration of such a transformation does not always coincide by analyses of specimens removed at operation and autopsy.

In considering the possibility of chronic lead poisoning from retained projectiles it is

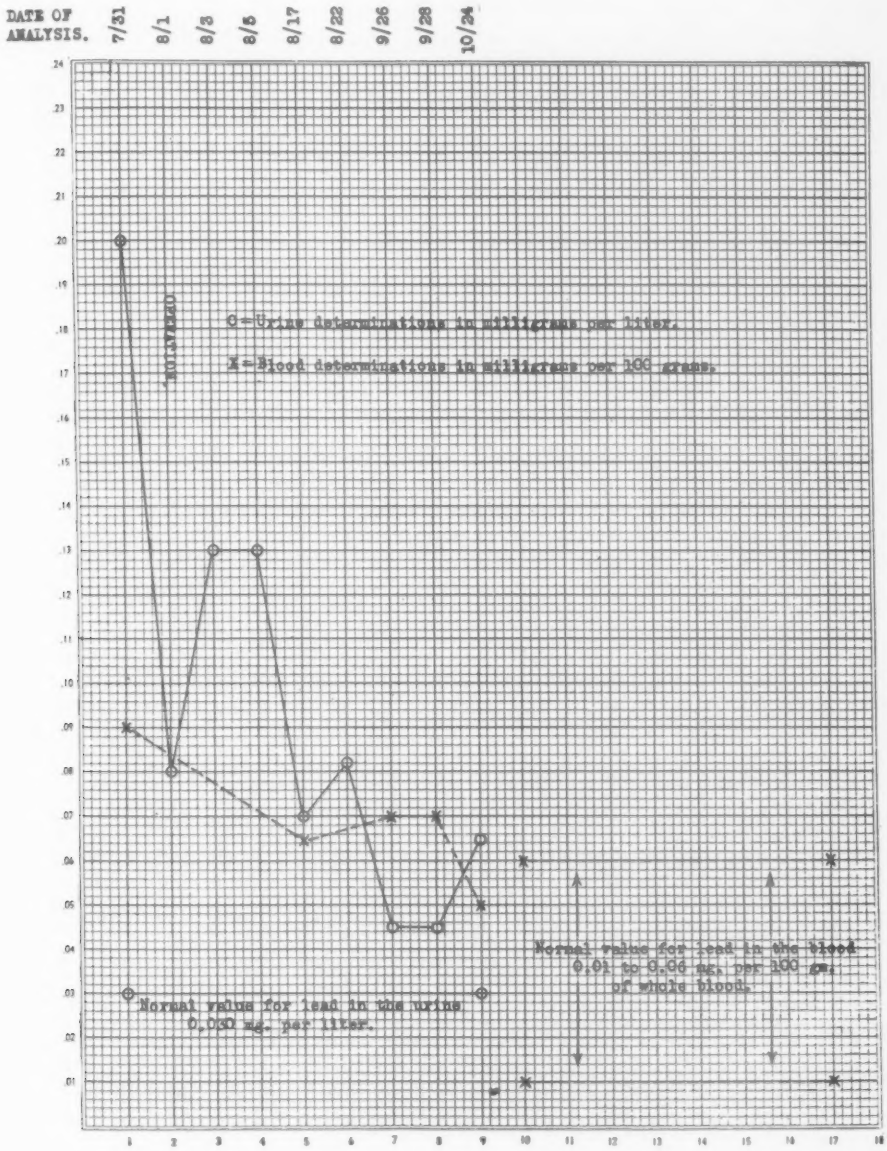

Fig. 7. Graphic representation of the chemical and spectrographic analyses for lead in the blood and urine showing the rather marked initial drop following operation.

with a clinical picture of lead poisoning. It does, however, serve to indicate that absorption in sufficiently large quantities is a potential danger. These signs of saturation of the tissues with lead have been confirmed of some importance to know the nature of the foreign body. Those projectiles such as infantry shot or shrapnel which consist for the most part of lead are more likely to result in disintegration and absorption than

grenade fragments or aerial bomb splinters which consist mainly of steel. In civil life the greatest number of wounds would result from small arms, and the lead content of these is very high. It is significant that none of these reported cases was concerned with bird shot or buck shot.

Probably the most important factor in the determination of the likelihood of disintegration occurring is the site of the embedded projectile. Of the 9 cases that are reported in detail in this paper, all but one were in bone and adjacent to an active joint. In Taltavull's[16] case the projectile was buried in the soft tissues adjacent to the greater tuberosity but did not involve the femur. The projectile is located in the region of the hip joint in 3 cases, in the region of the knee joint in 2 cases, in the wrist joint in 2 cases, in the small joints of the spine in 1 case, and finally, in the tarsal bones. This is apparently very significant and it has been suggested that the constant motion of the joint surfaces mechanically furnishes a destructive friction responsible to a great extent for the disintegration of the bullet. Projectiles which remain embedded in soft tissues have not been known to show these changes. They soon become encapsulated and innocuous. What part, if any, the synovial fluid plays in the solution of the lead, is not known and would seem to warrant further investigation. Whether the fragmentation of the projectile plays an important part or not is controversial. It would seem that with greater fragmentation, a greater surface area is available for absorption, and other factors being equal, greater absorption would occur from numerous small fragments than from a single large mass. This fact is not substantiated in the cases in which the films which were made at the time of the initial injury are available for study. In our second case the main mass of the bullet was practically intact at the time of the initial wound, and Haenisch's case shows very little fragmentation of the pistol ball in the earlier roentgenograms.

The interval between the gun shot wound and the onset of clinical symptoms varied in this series from one to twenty-two years. Nimier and Laval[13] state that symptoms appeared as soon as four weeks after the injury, while Bronvin[2] mentions twelve weeks as the shortest period before the development of symptoms. It is very probable that the absorption of lead does not take place continuously and in equal amounts. Many variable individual factors may be responsible, such as the general state of health and the absorption-excretion ratio.

The practical importance of these findings cannot be overemphasized. Those individuals known to have retained projectiles, especially, as in this series, buried in bone adjacent to active joints, should have serial roentgen examinations to detect those changes which we have described. Obscure and unexplainable symptoms referable to the blood, gastrointestinal tract, or nervous system may find their solution by this means. If changes occur in the projectile, demonstrable roentgenographically, then operation should be considered, even though no clinical or laboratory findings of chronic lead intoxication have been discovered.

SUMMARY

There are certain changes which may take place in the appearance of projectiles which have been retained in the body for a varying period of time and these changes can be demonstrated roentgenographically. They consist of diffusion, infiltration, and saturation of the adjacent tissues by lead particles. These changes have been associated with clinical and laboratory evidence of increased lead absorption, which had progressed in some cases to signs and symptoms of severe chronic lead intoxication. Projectiles lodged in bone adjacent to an active joint have shown these changes more consistently than those situated elsewhere in the body. The roentgen demonstration of these changes are of great diagnostic and prognostic significance in that subclinical lead intoxication with its varied and confusing symptomatology can be suspected and proper treatment instituted. The recog-

nition of the existence of these roentgen signs and their significance is stressed.

I wish to acknowledge the kindness of Dr. J. Albert Key in granting permission for the use of the roentgenograms of his case and of Dr. Joseph A. Freiberg for making the clinical records of the patients available for reference and study.

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POST-TRAUMATIC PARA-ARTICULAR OSSIFICATION OF THE KNEE JOINT

(PELLEGRINI-STIEDA'S DISEASE)

By J. KULOWSKI, M.D., F.A.C.S.
ST. JOSEPH, MISSOURI

DESIGNATED in the past by various proper names and descriptive terms, this lesion is characterized by a post-traumatic well defined calcification and/or ossification in the region of the medial femoral condyle. Pellegrini in 1905 was the first to study and emphasize the clinicopathological significance of this condition. Stieda's contribution was published in 1908. General interest in this disease is evidenced by such reports of large series from single sources as: Perocchia, 39 cases; Finder, 42 cases, and Bistolfi, 78 cases. Including post-traumatic para-articular pathological processes of all the articulations of the body, Pellegrini, in 1938, collected 767 cases from the world literature, a large proportion of which affected the knee joint.

An editorial in the July issue of the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY in 1932 introduced the subject in the American literature. Fram of South Africa described the incidental roentgenographic findings in a case in 1933. In the same year I reported the clinicopathological findings in one case from Steindler's clinic. Since that time approximately 60 cases, affecting the knee joint, have been mentioned in the English language, of which number data for statistical purposes are available in 20 instances (Table 1). I wish to report 11 additional cases, 7 of which were supplied by Dr. A. Steindler.

INCIDENCE

Finder's 42 cases represented 3 per cent of the knee injuries from the orthopedic clinics of Cook County Hospital. Bistolfi reviewed 767 roentgenograms of traumatic lesions of the knee joint. Three hundred and thirty-six revealed a variety of bone lesions of which 78 proved to be typical para-articular ossifications; a general incidence of 10 per cent of all injured knees or 23 per cent of those which revealed definite roentgenographic evidences of trauma.

The male sex is predominantly affected. In Finder's series the ratio of males to females was 5:2. In the cases tabulated in Table 1 there were 14 males and 6 females. In the present series there were 8 males and 3 females. Male predominance is probably due to the medicolegal interest incidental to industrial injuries.

The ages of reported cases ranged from twelve to seventy-one years. The greatest number occurred between the ages of thirty and forty years. The disease is not uncommon in the age groups of twenty and fifty. It has been noted in only 4 instances before the twentieth year and has not been observed in very young children (Petrignani). In Table 1 the ages ranged from eighteen to sixty-one years and in the present series from sixteen to fifty-two years.

PATHOGENESIS

Trauma as the inciting factor is evident in practically all cases. Isolated or repeated minimal trauma incident to occupation may be responsible but difficult to prove. A history of antecedent direct, and to a lesser extent indirect, trauma predominates. The accident is usually gross in character. When antecedent trauma is absent some other etiological factor or process should be suspected. In Bistolfi's series (1) 76.9 per cent resulted from sprain; (2) 14.1 per cent followed direct contusions; (3) 6.41 per cent were due to fragmentary or chip fracture, and (4) in one case the lesion formed about or around an isolated bone fragment.

Pellegrini speaks of the relation of the

nature of the injury to the subsequent anatomical characteristics of the process as follows: (1) Those secondary to sprain are small and present regular well defined margins. (2) Those secondary to or around a hematoma are more squat, globular and irregular in outline. (3) Those which follow mobilizing maneuvers on ankylosed joints are voluminous and irregular. He quoted Petrignani to the effect that the process was longitudinal after sprain, transverse after contusion and expansile in both directions after sprain contusion.

The developmental activity and rate of growth of the calcification may be precocious or delayed. Benassi (1931) noted roentgenographic shadows at two, eight and nine days after injury in which definite ossifications occurred soon after. Since the relation of this lesion to its antecedent trauma is of medicolegal importance, one should avoid hasty judgment. The interval between the injury and its consequences is very variable. The lesion may not become manifest for as long as a month after injury. Some experts refute the etiological relationship of an antecedent injury if the condition is manifest before the fifteenth day after the injury was sustained. When the process is seen immediately after an injury, a preceding or remote trauma should be suspected. Pellegrini has not observed the roentgenographic shadow before twenty-five or thirty days and states that typically the formation ceases to develop further after thirty or forty days. However, atypical instances remain active over long periods and do not reach maturity for many months. Bistolfi

TABLE I

TABULATION OF CASES OF PELLEGRINI-STIEDA'S DISEASE REPORTED IN THE ENGLISH LANGUAGE

Author and Year	Age of Case in Years	Sex	History of Trauma	Duration of Symptoms	Presence of Associated Conditions	Treatment	Comment
Fram, 1933	38	Male	Antecedent and recurrent	18 mo.		None	Incidental finding
Kulowski, 1933	29	Male	Antecedent	3 mo.		Excision	Extensive recurrence of calcification
Finder, 1934	Discusses 42 cases	Male				Excision and plastic of ligament in 1 case	Partial recurrence; good functional result
Ritvo and Resnik, 1934	38	Female	Antecedent	6 wk.		Physiotherapy	Cure in 4 mo.
Riebel and Riebel, 1934	47	Male	Antecedent	23 days		Excision 6 mo. later	Recurrence with symptoms
Hedrick and Jones, 1934	38	Female	Antecedent	21 days	Degenerative arthritis	Physiotherapy	Improved
	45	Female			Chronic proliferative arthritis	None	Incidental finding
	61	Male	Antecedent	5 yr.	Arthritis	None	
	23	Male	Antecedent	2 mo.		Aspiration and cast	Relieved in 3 wk.
	45	Male	Antecedent	3 wk.	Fracture head of fibula	Cast	Relieved in 3 wk.
Oxford, 1935	55	Male	Antecedent	1 mo.		Cast	Cured
Rachlin, 1934	54	Male	Antecedent	9 mo.	Para-articular ankylosis	Excision	Good result
Miller and Miller, 1935	45	Female	Antecedent	2 mo.		Physiotherapy	Cured
Wetzler and Elconin, 1935	24	Female	Antecedent	7 mo.		None	Spontaneous cure
	27	Female	Antecedent	7 wk.		None	
	25	Male	Antecedent	4 mo.		None	
Henson, 1936	48	Male	Antecedent and recurrent	7 mo.	Fracture of the calcified process	Excision and electrocautery	Excellent result
	18	Male	Antecedent and recurrent	7 mo.	Myositis ossificans	Biopsy	
Hinson and Gerald, 1937	21	Male	Antecedent	6 wk.		Under treatment	
Coltart, 1938	40	Male	Antecedent	6 mo.		Excised 6 mo. later	Recurrence; good functional result

noted that the growth develops relatively slowly after sprain in contrast to the more rapid growth following contusions. This is in accordance with Petrignani who found that indirect trauma relates to stable forms while direct trauma results in the evolutive types of the condition.

Regression of the lesion is manifested rarely by vacuolization and even by complete disappearance (Drant). Bistolfi noted a doubtful resorption in only one case. He did note a tendency toward reduction in size in exuberant formations paru passu with increased condensation, somewhat like that observed in callus formation. It may be seen from Table 1 that the earliest lesion was noted within three weeks of the antecedent trauma. In the present series the earliest appearance was noted (on roentgenograms) within twenty-four days after the injury, and the longest apparent duration of symptoms was three and a half years. Spontaneous resolution of the process was observed in 2 cases of the present series under widely divergent conditions. In the first instance, the lesion disappeared when biological fusion had been surgically accomplished for an associated tuberculous condition of the knee joint. In the second instance, the lesion which followed an arthroplastic procedure disappeared after subsequent mobilization.

REGIONAL ANATOMY

The normal femur possesses two epicondyles to which are attached ligaments and muscles. Often these are merely roughened areas instead of protuberances, especially on the medial side. To the medial epicondyle is attached the medial tibial collateral ligament, the medial head of the gastrocnemius muscle, particularly the medial portion, and the adductor magnus. The lower part of the latter covers the medial head of the gastrocnemius. The medial collateral ligament is attached at the more flattened distal portion of the epicondyle, while the adductor magnus and gastrocnemius insert at the upper or proximal portion. This upper condylar portion, which continues upward with the medial rim of the linea aspera, sometimes forms a protuberance.

THEORIES OF ETIOLOGY

The three current theories, which attempt to explain the development of the lesion state that it is the result of: (1) separation of a bony fragment; (2) periosteal ossification; (3) calcification of the soft parts with subsequent ossification (metaplasia).

Pellegrini's original classic description still forms the basis of present day discussion concerning the development of the lesion. His patient was a laborer, aged thirty-six, whose lesion was surgically removed forty-eight days after a severe direct injury. The mass was adherent proximally and extended downward along the medial collateral ligament of the tibia. Microscopically a central zone of ossification extended toward a more homogeneous peripheral structure. There were no osteoblasts at the proximal limits of the ossification, and Pellegrini accepted this as proof that at least this portion did not ossify from periosteal osteoblasts originating from the femoral margin (although he admitted this possibility). Pellegrini concluded that the ossification in his case was the result of two distinct and combined processes: namely, periosteal proliferation and direct metaplasia of the ligamentous structure of the medial collateral ligament.

This mechanism explains the occasional bilaterality of the lesion, its wide variation in structure, shape and anatomical relationship to the medial femoral condyle, its evolution and occasional spontaneous regression, its recurrence after premature surgical excision, the incubation period or interval necessary for its development after trauma, and the usual presence of a free radiant space interposed between the shadow and the free margin of the medial epicondyle.

Stieda (1908) on the basis of 5 cases clinically observed, anatomical studies, and by analogy to a museum specimen exhibit-

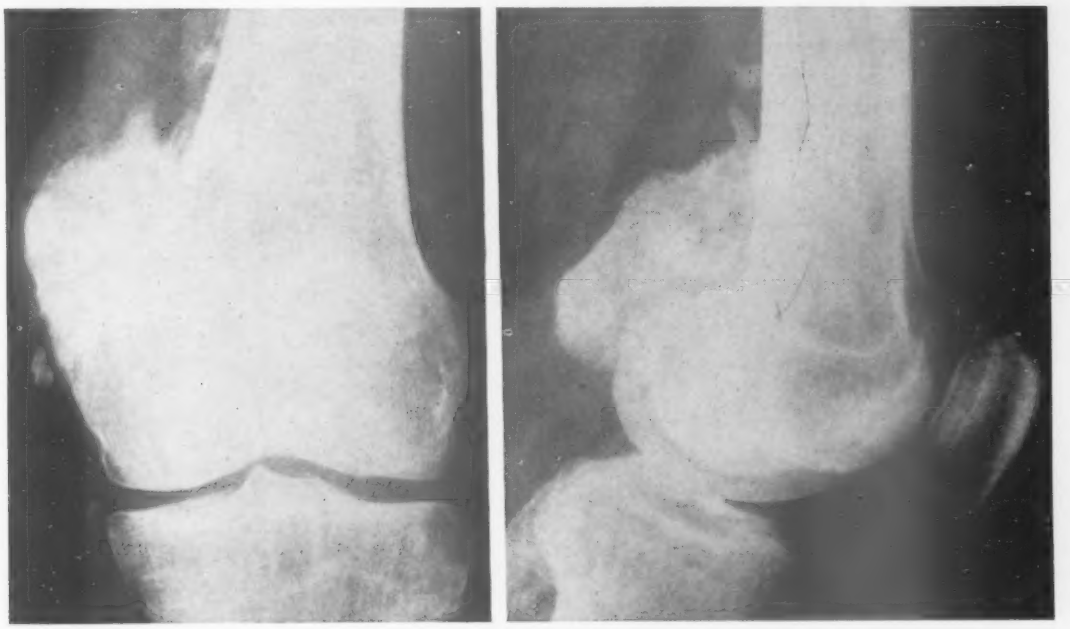

Fig. 1. Exuberant postoperative recurrence of ossification along with appearance of separate nuclei in the medial collateral ligament.

ing a fracture through the medial epicondyle of the femur, argued that the lesion represented an avulsion fracture fragment of the epicondyle; since the position of the shadow related it to the upper portion of the condyle where muscles insert rather than to the lower portion to which the medial collateral ligament is attached.

Koing (1909) suggested that the process might be the result of periosteal avulsion and proposed the term "fractureless callus formation." Ternler believed, from the form and position of the shadow, that it would correspond to the intermuscular space between the adductor magnus and vastus internus. Since conditions for resorption of blood clot are unfavorable here calcification might result from small hematomas in consequence of capillary hemorrhages so characteristic of postoperative recurrences (Fig. 1).

HISTOPATHOLOGY

Microscopic studies of surgically removed material have tended to support the hypothesis that the lesion is due usually to metaphasia of the affected ligamentous structures. Other mechanisms of formation may, however, be operative in the individual case. Callen relates the condition simply to well known factors concerned with calcification in tissues which are dead or in a state of reduced vitality. Since fatty degeneration precedes calcification this may explain the interval or lag following injury until the shadow becomes manifest. Growth or diminution of the process may then be dependent upon the state of vitality of the tissues sensitized or affected. Since bone is a secondary tissue it must be preceded either by cartilage or fibrous tissue. The mass may begin from two or more separate and distinct nuclei. Usually the peripheral portion of the mass is partly fibrous and partly cartilaginous. The central portion is usually osseous but sometimes calcific. A highly developed process shows central spongy tissue surrounded by a ring of dense osseous tissue at the periphery. The following microscopic study from a case of Steindler's is illustrative:

The tissue grossly presented an osseous body embedded in dense ligamentous tissue. The tendinous tissue near the bone is

edematous (pre-osseous edema?) and the cells round rather than spindle shaped but still parallel in arrangement. This layer of edematous tissue merges with the bone. Fibers of ligament merge imperceptibly with the fibrils of the bone. The bone is living cellular bone, almost entirely composed of fibrous bone. The architecture closely resembles that seen in the very thin compacta over the metaphyses of a long bone. Along the walls of the larger vessel spaces is a row of osteoblasts and bone apposition is occurring. Often there is a thin layer of lamellar bone (of osteoblastic origin) along such a vessel space. This is demarcated from the fibrous bone by a blue cement line. Concentric layers of lamellar bone are found around some of the smaller vessel spaces. In a few areas osteoclastic resorption is taking place. Most of the vessel spaces are filled with a loose cellular vascular connective tissue.

DIAGNOSIS AND CLINICAL COURSE

The clinical symptoms which call attention to the possibility or eventuality of Pellegrini-Stieda's disease are not pathognomonic of the lesion but are common to most injuries of the knee joint. Knowing the nature of the injury the occurrence of the lesion may often be prognosticated. A history of trauma when followed by pain, swelling, and restriction of joint motion should always be seriously considered. If after a sprain or contusion the pain continues beyond the period of recovery expected from the nature of the injury and/or the symptoms become intensified, a calcification should be suspected (particularly if passive movement and massage have already been instituted). Under such conditions future interval roentgen examinations should always be planned.

Tenderness is limited to the region of the medial femoral condyle and/or the collateral tibial ligament. Movements resulting in tension on these structures intensifies the symptoms. The severity and character of the disability vary with the nature of the injury and associated anatomical reactions and conditions. In cases seen months or years after the onset of the disease the pa-

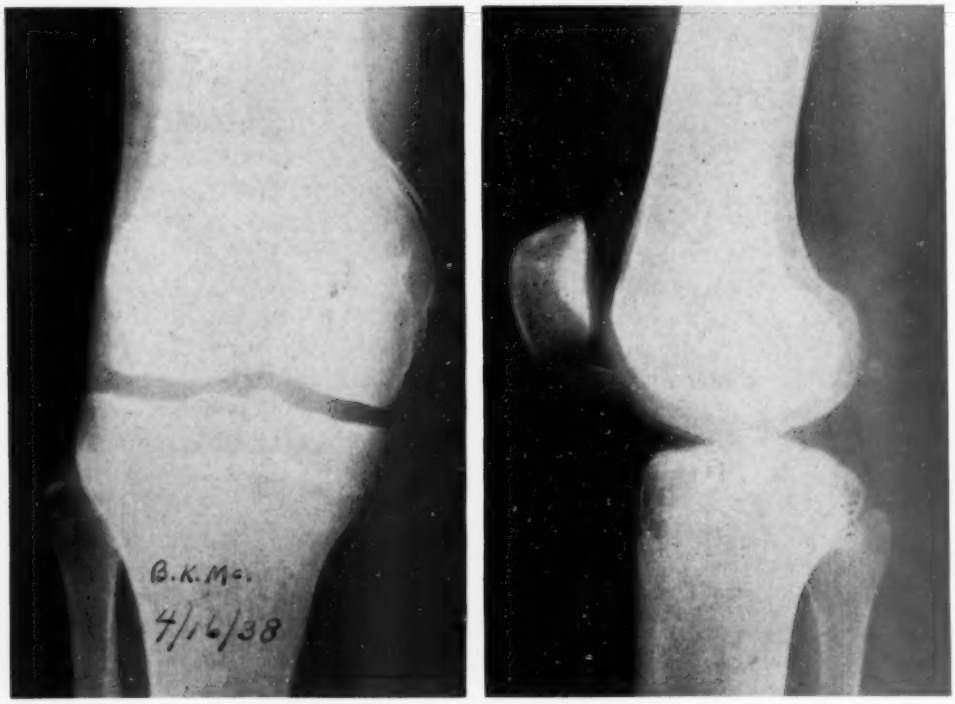

Fig. 2. Stabilized asymptomatic calcification associated with joint mouse.

Fig. 3. *A*, stabilized form associated with osteochondroma of the tibia. Spontaneous recovery. *B*, evolutive lesion associated with fracture of the lateral tibial plateau.

tient may complain of variable discomfort, limitation of joint motion, and fatigability incident to residual muscle atrophy, arthritic or other complications. On examination early there is a sense of resistance, infiltration or thickening of the soft tissues on the inner aspect of the knee, which may be more prominent than the opposite unaffected region. Later the calcified mass may be palpable. The mass is hard, usually slightly movable, and is not attached to the skin overlying it. Occasionally atrophy of the thigh and calf muscles along with slight circumferential enlargement at the level of the lesion is noted. Laxity or restriction of joint motion may be found, and in one reported case an almost complete ankylosis resulted from extensive calcification of the ligament. Secondary transitory swelling of the joint is not infrequently observed.

Clinically it is necessary to exclude or include associated conditions causing internal derangement such as joint mouse, fracture or cyst of the meniscus, rupture of a cruciate ligament, avulsion of the tibial spine, detachment of the tubercle, isolated injury to the medial collateral tibial ligament and other tendon or bursal structures (Figs. 2 and 3). The mechanism that produces an internal derangement of the knee joint may also cause a concomitant injury to the medial collateral ligament and/or adjacent soft or bony structures. The presence of one does not therefore necessarily exclude the existence of the other.

Associated conditions are important from the standpoint of etiology, diagnosis, incapacity, treatment and medicolegal interest. Table 1 lists a variety of these which were for the most part due to the injury which resulted in the pathological process in question. It may be noted that fracture of the process itself was observed in one of Henson's cases. Curiously enough Pellegrini's original roentgenogram also shows an unmistakable division of the shadow near its distal extremity, which, however, might have been the result of its develop-

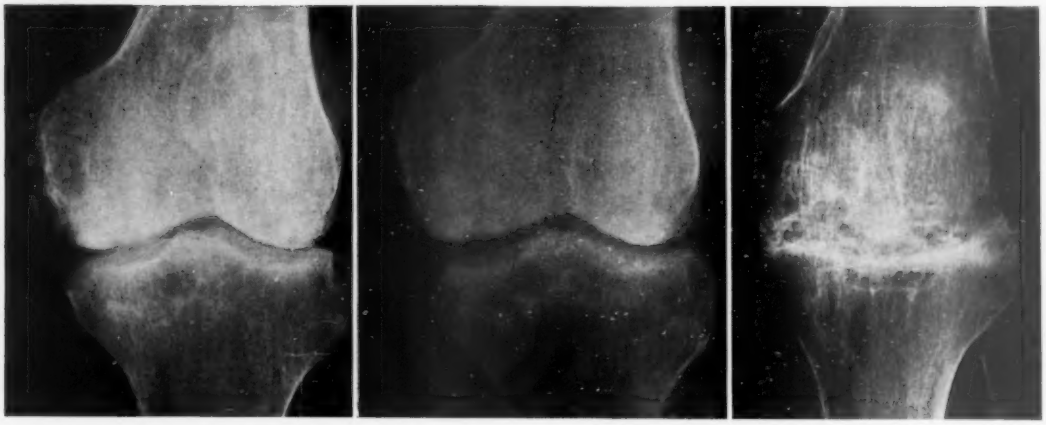

Fig. 4. Case x. Serial roentgenograms of calcification associated with tuberculosis. Spontaneous resolution, following operative fusion of the joint.

ment from two distinct nuclei. Henson's second case presented an associated myositis ossificans mass; apparently one or the other had resulted from a recurrent trauma. Since arthritis was present in 3 instances its importance as a possible or predisposing or etiological factor is suggested.

In the present series associated conditions were noted following trauma which affected the knee joint as well as other unrelated structures, depending upon its severity and mechanism. The most interesting was that of a tuberculosis of the affected knee joint (Fig. 1). The history of this case leaves no doubt that the ossification preceded the specific inflammatory event. Another instance presented a post-traumatic process and defect of the patellar articular surface and joint mouse (Fig. 2). An internal derangement of the opposite knee served to confuse the issue in one case from the medicolegal angle. In my last case there was also present a hypermobile meniscus, rupture of the anterior cruciate ligament and a calcified synovial tag.

ROENTGEN FINDINGS

The final diagnosis rests entirely on the roentgenographic findings. Initial swelling in the typical location before calcification occurs may be suggestive when taken for soft tissue detail. This technique is essential in any instance for accurate study of the evolution of the lesion and for medicolegal considerations. True anteroposterior views demonstrate the shadow best, since in the oblique or lateral view the mass may be masked due to overlapping or appear to be attached to the femur.

Pellegrini stresses the importance of systematic repeated roentgen examinations fifteen, thirty and forty or more days after trauma. This is particularly true of those cases where persistent pain and limitation of motion are present which cannot be explained on the basis of the primary injury. He warns that roentgen examination should always precede attempts at manipulative mobilization or massage therapy in any instance of knee joint disability. He further suggests that soft rays or sub-exposure is necessary to detect the early soft tissue process. More detail can be obtained without the use of reinforcing screens. It is an excellent idea to make two exposures, one hard and one soft. Bilateral views give a good opportunity for comparative study and evolution of the lesion. Stereoscopic views and intra-articular oxygen insufflation will differentiate between intracapsular, extracapsular, or intercapsular pathological processes.

One cannot differentiate calcification from ossification roentgenographically when there is no evidence of trabeculation. The density of the shadow depends upon

its age, being more translucent in recent and more dense in its later development. The density or tonality is not always uniform, and areas of less dense and more dense qualities reside side by side. During the period of growth the contiguous portion of the condyle decalcifies but returns to normal density when the peri-articular process matures.

Ordinarily the shadow on the roentgenogram is characteristic in size and shape. It is usually directed vertically or slightly obliquely and may be crescent, elongated, vermiform, triangular, fusiform, island, sequestrum, fragmented or spicule. Depending upon its relative position, it may be proximal, central, distal or combined. *Characteristically there is a clear radiant space of varying degree between the shadow and the femoral condyle.* This is of importance in ruling out osteoma, periostitis, fracture of the femoral condyle and to a lesser degree parosteal arthropathies.

Depending upon the stage of development, two main types are recognized: the evolutive and stabilized forms (Petrignani) (Fig. 5). The former appears as an active, more or less hazy or fuzzy variegated opacification of the adjacent connective tissue. The latter is a mature, well defined, dense, sharply outlined calcific or ossified shadow which forms a residual covering over the medial femoral condyle. Its dimensions vary from 0.5 to 8.0 cm. and the thickness from a 2 mm. strip to 0.5 cm. It may enlarge in all diameters as the disease progresses but remains fixed when final maturity is gained.

The shadow is often variable in shape and size. The most common are characteristically thin, elongated, follow the condylar contour, are lamellar and present clear cut margins in a convex, and concavoconvex manner. More often they terminate distally, narrowing down, assuming the form of a scythe or half moon and less frequently are beaklike. They are situated more or less close to the bone. Only rarely do they adhere to the bone and that partially at one or the other extreme. Rarely the shadow is voluminous, irregular and fuzzy in outline. Exceptionally they assume a cap-like or ring shape.

PROPHYLAXIS AND TREATMENT

Of paramount importance in prevention and prophylaxis is the rational initial treatment of ligamentous sprain. It is evident that early mobilization and overzealous

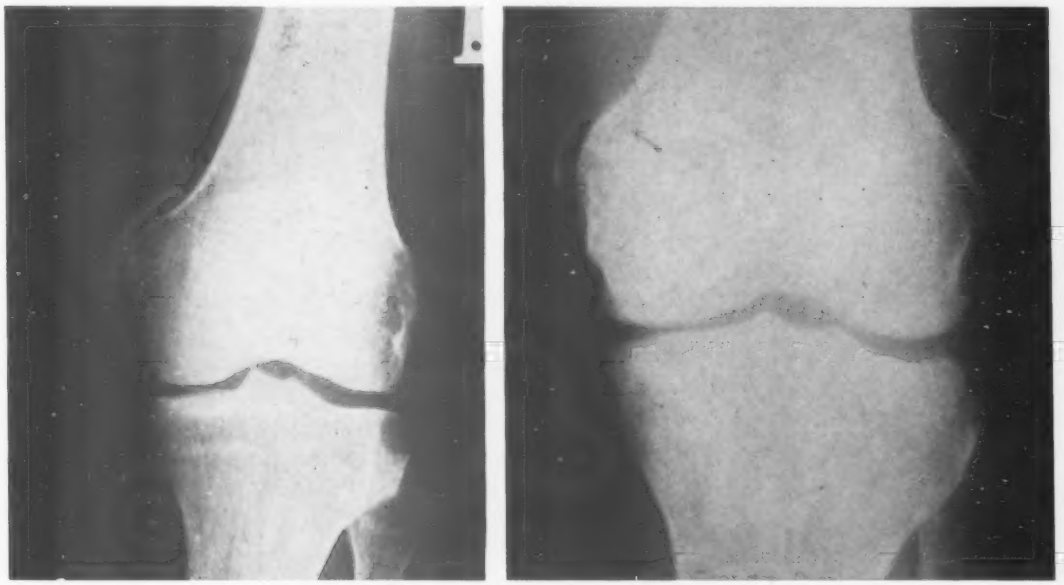

Fig. 5. Showing typical evolutive (left) and stabilized lesions (right).

massage are contraindicated. Leriche records brilliant results from anesthetic injections into the traumatized tissues on the basis of his theoretical conception of sprain as a lesion of the intraligamentous nervous system. By blocking the sympathetic reflexes which run efferently from the traumatized region the pain and its reflex consequences are thereby suppressed.

A satisfactory regimen of treatment of the lesion must devolve on the clinician, on the merits of the individual case. Both conservative and radical measures have been tried with varying degrees of success. Immobilization, physiotherapy, surgical extirpation or non-interference may be indicated. Surgery is contraindicated until full maturation of the lesion has taken place since tissues already sensitized to the formation of bone may initiate recurrence of the growth.

Table 1 lists 6 cases which were subjected to surgical excision of the lesion, 9 cases which received no treatment, and 5 which received immobilization along with various forms of physiotherapy. In the operated group there were 4 recurrences, with good function despite that fact in 3 instances. Spontaneous healing was observed in one instance after seven months. Symptomless lesions require no treatment. Associated major local disabling conditions should always claim prior therapeutic consideration. It is reasonable to assume that a therapeutic test of rest and physiotherapy should precede any surgical intervention. When operation is decided upon, wide excision along with thorough electrocauterization and plastic repair when necessary would seem to offer the best chances for cure and good functional recovery.

Excision is indicated when the ossification provokes marked disturbances but should only be done after the process has reached a so-called static state of maturity. It may then be considered to be a true foreign body which can safely be removed as such. Bacci proposes the interposition of a pedunculated piece of fat at the site of ossification since fat ossifies so rarely. His operative results were good in a great percentage of cases. Pellegrini considers the results of operative treatment as recorded in 23 cases in the literature to be good: there were 17 cures, 2 recurrent, and results unknown in 3 instances. In the present series of 11 cases excision was indicated and performed in only 2 instances with good results.

Bellucci says that radiation therapy is most efficacious but Dewitte warns that this form of treatment be used advisedly since there is some doubt as to the occurrence of complete healing following its use. Another author states that irradiation slows or attenuates the pathological process. The choice of roentgen irradiation as the method of treatment is somewhat dependent upon a distinction between recent and stabilized lesions. In recent cases roentgen irradiation may result favorably. In mature stages, though the lesion is not influenced by irradiation, pain may be diminished and muscle spasm decreased. Roentgen irradiation may also be used in the prophylactic sense and is advised before and after operative excision.

MEDICOLEGAL PHASES

It is an interesting fact that Pellegrini emphasized the medicolegal aspects of the problem in his original paper thirty-five years ago. He concluded that the lesion was a true post-traumatic process received in the line of occupational duty. I feel that in the light of present day knowledge the incapacity from an uncomplicated lesion, properly managed from the inception of the injury, may be expected to be nil or minimal. In the present series of cases no disability ratings were accorded in the several instances which were examined for insurance companies. Bacci (1937) evaluated 10 cases as follows: no permanent disability in 6, 6 per cent in 2 and 8 per cent in 2 cases.

Pain may persist as a residual sequela, and may be spontaneous or provoked on movement of the joint even in a mature lesion. On the other hand, some lesions re-

main insignificant if the patient is not informed about it. A rating should be based on correlation of the roentgenographic and clinical findings. The former reveals the form and outline of the mass. The more annoying lesions have rough profiles which may be irritative. It is evident that compensation ratings will be very variable and may be decided as follows: according to the part of the joint structures affected, development of the lesion, its relation to surrounding tissues, elements of the articulation involved, presence of pain, functional limitation and existing associated conditions.

As a rule, the disability is only temporary although sometimes of rather long duration. In general, the disturbance is slight when only the medial epicondyle or proximal extremity of the ligament is involved, and there are no other concomitant lesions. Sometimes there is pain only after weight bearing activity under particular disadvantages such as downhill locomotion, the carrying of heavy loads or occupational activity which results in lateral movements of the knee joint. The patient may return to work when the pain and restriction of joint motion are gone.

Bistolfi states the permanent disability ratings as established by Lusena as follows:

(1) No indemnity when the ossifications are of slight extent and when no atrophy or joint changes are present.

(2) Minimum rating (about 5 per cent) when the atrophy and joint changes are of a slight degree or when the lesion itself is conspicuous. A rating of more than 10 per cent was rarely given and that only in cases with associated lesions of the articular elements.

(3) When the degree of functional limitation is grave then the percentage is increased. In these cases only a small part of the disability is attributable to the ossification.

CASE REPORTS

Case I. B. C. Mc. (1938), white married male, aged twenty-five, truck driver. He stated that thirteen months previously the rear loading door of his truck opened down upon the right kneecap. Severe pain, swelling and "catching" followed almost immediately, and subsequently there developed episodes of painful "locking" of the knee joint. Physical examination eliciated nothing of note but the roentgen examination revealed a joint mouse, and an unsuspected stabilized shadow suggesting Pellegrini-Stieda's disease apposing the entire medial femoral condyle. The joint mouse was removed and the articular patellar defect revised. The calcified area was not disturbed. He returned to work in ten weeks. Six months later roentgenograms showed no change in the medial shadow, and there were no residual symptoms referable to it. His incapacity rating was based only on the patellar defect (10 per cent). Thirteen months after operation the patient, who was now employed as a bus driver in another city, wrote that following continued heavy braking he noted slight swelling of the knee but no disconfort.

Case II. B. N. (1939), white male grocer, aged fifty-two, stated that eleven days previously he had fallen down an elevator shaft for a distance of 10 to 12 feet, thus injuring his right knee. Pain, swelling and stiffness immediately followed and had persisted. Examination revealed no gross limitation of motion. *There was extreme tenderness over the upper lateral margin of the femoral condyle, slight infiltration of the adjacent soft parts*, but no palpable mass. Roentgen examination twenty-four days after his injury revealed a suspected evolutive shadow suggestive of Pellegrini-Stieda's disease opposite the upper femoral epicondyle. He was immobilized in a cast for three weeks and diathermia applied for several weeks thereafter, with resultant gradual improvement. Three months later extension of the knee joint was associated with a snapping sensation. At that time his attorney was notified that the permanent partial incapacity was expected to be minimal and that surgical intervention would probably never be indicated. An out of court settlement was soon effected. Examination thirteen months after his injury now showed a well stabilized shadow, but the joint was subjectively and objectively symptom free.

Case III. J. R. (1939), white male, aged thirty-five, automobile mechanic. Sixteen months previously the patient had been jammed between a truck and the garage wall. Immediate painful symptoms were referred to

the left knee. Roentgenograms of the affected knee joint were negative. He remained in bed two weeks and then experienced frequent sensations of "catching" and episodes of "locking" in the left knee, which had gradually subsided. He returned to work three months after his injury. Since that time he had been having definite discomfort in the right knee. Squatting and stair climbing produced a "popping" noise. Pain was constant, and was associated with pressure tenderness over the medial side of the knee joint.

Examination of the left knee revealed only slight tenderness over the medial collateral ligament. The right knee motions were accompanied on extreme flexion and initial extension by an audible click. A point of maximum tenderness was elicited at the posterior border of the medial collateral tibial ligament and joint meniscus. Roentgen examination of both knees was negative on the right, but showed an unsuspected but typical stabilized shadow suggesting Pellegrini-Stieda's disease on the left bordering the upper third of the epicondyle. For the past year the patient has been attending to his regular duties.

CASE IV. J. M. (1940), white male, aged fifteen, complained of inability to straighten the right knee for the past eight months, following a severe sprain. Since that time certain movements have caused episodes of transient pain, swelling, audible "pop," and a sensation of giving way. The right knee was 1 inch greater in diameter than the left. The medial condyle was more prominent on the right. In the region of the medial collateral ligament a small tender movable mass was palpable. The roentgenogram showed several small, globular, discrete areas of calcification approximating this region.

At operation the medial meniscus, which was found to be extremely hypermobile and shredded anteriorly, was excised. The anterior cruciate ligament was gone; a small remnant remained at its tibial attachment. An intra-articular spherical bony mass, the size of a pea, was covered by and attached to the synovial membrane near the attachment of the medial collateral ligament, by a thin pedicle about ½ inch in length. Exposure of the medial collateral ligament revealed a similar mass embedded in the ligament at its attachment to the condyle. When this was shelled out the opposing surface of the femoral epicondyle was slightly granular. The ligamentous defect was plastically repaired. The ruptured anterior cruciate ligament was not reconstructed at the time. There has been no recurrence of the calcification after six months.

CASE V. F. H. L. (1936), male, aged forty-six. Due to a recurrent type of backache the patient had been "lifting from his knees" for several years. For some time both knees had been mildly and occasionally painful. Lately he had experienced a slight "catch" in the left knee. Four months previously he had stepped down suddenly from a ladder on his left foot and immediately experienced severe pain and swelling in the left knee. Examination revealed slight shrinkage of the left thigh musculature which was unassociated with any restriction of motion, instability or tenderness. Roentgenograms of both knees showed nothing remarkable on the left side. On the right side, there was a small calcific deposit at the adductor insertion, which was apparently attached to the periosteum.

CASE VI. P. R. W. (1933), male, aged thirty-three, complained of instability of the right knee. He stated that this joint had been sprained twelve years previously but had been all right until three months ago. At that time, while he was dragging some telephone wire over his right shoulder, the right knee had suddenly snapped into a severe painful hyperextension. He was able to continue his work. He experienced severe pain for three days, which was associated with swelling over the medial border of the knee. He was symptom free in ten days, and has remained so. The local physical examination was entirely negative. Roentgenograms of the affected knee showed a stabilized ossification typical of Pellegrini-Stieda's disease approximating the medial border of the femoral epicondyle. The patient was told to resume his former duties and that he would have no disability as the result of his injury.

CASE VII. W. M. (1939), male, aged forty-nine. He complained of pain in the right knee for four months following a fall downstairs. Severe pain, flexion deformity, and swelling immediately followed the injury. The next day his physician manipulated the joint into full extension, immobilized the joint with adhesive strapping for three weeks, and applied heat and massage thereafter. The patient continued to experience pain over the medial side of the knee but only on weight bearing. Examination revealed local tenderness over the medial epicondyle on the right. Roentgen examination in-

dicated a slight calcified shadow in this region. Physiotherapy and support to the knee were instituted for one month without relief.

At operation the calcified mass was definitely movable, and was shelled out of the medial collateral ligament. The opposing surface of the femur was then noted to be slightly roughened. The ligamentous defect was repaired and closure in the usual manner followed. No cast was applied. He made an uneventful recovery and roentgen examination six months after operation showed no recurrence of the shadow, and the patient was practically symptom free.

Case viii. Mrs. L. P. (1936), aged forty-eight. The patient had sustained a fracture of the left clavicle and external condyle of the right tibia in an automobile accident eleven months previously. An open reduction had been performed on the latter five days after the injury. A small fragment of bone was removed along with a fractured portion of the semilunar cartilage. Mobilization followed a two weeks' period in a cast. Her condition progressed satisfactorily until three months after operation at which time she developed progressive dull, aching pain in the affected knee on weight bearing, associated with crepitation.

Some restriction of the extremes of flexion and extension of the knee was noted on examination. There was slight shrinkage of the thigh musculature. Stethoscopic auscultation revealed a dull thud over the lower outer quadriceps insertion and numerous lesser noises on movement of the joint. There was marked tenderness and thickening over the medial femoral epicondyle and behind the fibular head. Roentgen examination showed that the tibial fracture was healed in good position, but there was some evidence of osteo-arthritis of the joint. Most conspicuous was a well defined stabilized ossification in the region of the medial femoral epicondyle.

Case ix. W. A. (1932), male, aged thirty-three. He complained of pain and stiffness of the right knee for nine months. He had been jammed between a pile of coal and coal cars. His right knee had been snapped into hyperextension. Pain in the joint had been a prominent symptom since this accident. He had remained in bed one month and used crutches thereafter for some time. His pain was localized to the medial border of the right knee. It was dull aching in character and intensified by weight bearing. Occasionally he noted some swelling over this region.

Physical examination revealed tenderness over the adductor tubercle of the femur and motion of the knee was limited from full extension to 60 degrees of flexion. The roentgenogram revealed a stabilized calcified shadow in the region of the medial femoral condyle. The patient remained under observation for two months and was treated for other associated traumatic conditions of a more urgent nature. In the meantime the symptoms referable to the knee joint had spontaneously subsided.

Case x. P. S. (1929), male, aged twenty-three. Four and a half years previous to his first examination the patient had sustained a severe sprain of his right knee during a basketball game. He resumed the game in a week. However, he noted that the affected knee continued to be weak. Six months later he injured the same knee during a football game. Since that time the knee had remained swollen, painful and gradually stiffened. Seven months later a biopsy showed tuberculosis of the knee joint. He continued to work with the aid of a brace until two months before his admission to the clinic when a spontaneous sinus had appeared. Examination revealed a tender, swollen joint obviously the seat of a low grade destructive inflammatory process. Roentgen examination confirmed this and also showed a stabilized ossification fairly typical of Pellegrini-Stieda's disease. Following a period of conservative treatment the joint was fused (at which time biopsy confirmed the diagnosis of tuberculosis) surgically nineteen months after his first admission. Interval roentgen studies showed that the calcified shadow resolved spontaneously when biological fixation of the joint had been accomplished (Fig. 4).

Case xi. F. F. (1933), female, aged twenty-six. The patient entered the clinic three years after an onset of infectious arthritis of the left knee which was followed thereafter by multiple joint involvements. An arthroplasty of the left ankylosed knee joint was performed. Curiously enough a typical shadow appeared in the region of the medial femoral condyle after operation which went through the usual evolution and finally resolved and disappeared spontaneously in spite of early postoperative mobilization.*

* Since this paper was accepted for publication I have noted 2 more typical cases, one in a male aged forty-one, and the most recent instance that of a boy aged sixteen years.

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BONE INFARCTS*

By S. C. KAHLSTROM, M.D.
BATH, NEW YORK

AS RECENTLY pointed out by Phemister,[8] bones have been known to contain end-arteries since the studies of Langer in 1875, yet knowledge of changes in bones following vascular occlusion has developed slowly. The works on pathology that even mention infarcts of bone are few indeed; the topic is listed but three times in the *Cumulative Index* prior to 1939.

Changes in the carpal, tarsal and metatarsal bones and the articular ends of the femur in particular, consequent upon vascular occlusion, are rather fully discussed in the more recent surgical[8,9] and roentgenologic[1,4,7] literature, but references to infarcts of the shafts of long bones are still relatively infrequent. The explanation probably lies in the fairly silent nature of these lesions. Their roentgenographic discovery is usually accidental and biopsy studies are deemed unwarranted in the absence of symptoms. During autopsy, the pathologist rarely has occasion to study the long bones, and infarcts are overlooked unless a preliminary survey has been made of the roentgenograms.

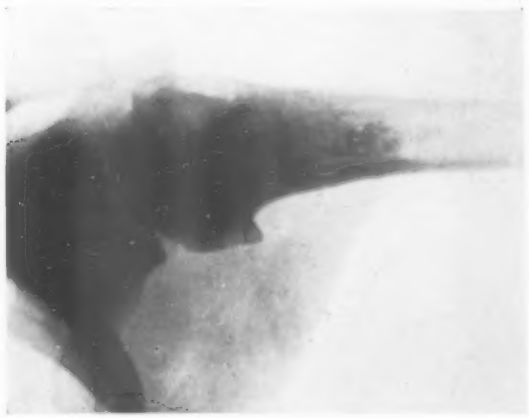

FIG. 1. Case 1. Left shoulder in abduction. Irregular calcific deposit of old infarct in the medullary portion of the humerus, extending through the epiphysis to the articular surface.

The roentgenologic features of infarcts of the diaphysis are quite characteristic, with well-defined, often symmetrical mottled areas of increased density involving the medullary portions of the diaphyses, sometimes extending into the epiphyses. Involvement of the non-articular cortex is infrequent. The size varies from mere flecks to several decimeters. The larger lesions are often separated from the normal bone by a narrow zone of calcification, and frequently contain cystic areas with surrounding calcification. The necrotic bone may become completely calcified, leaving a homogeneous, dense, nonreticulation defect.[3]

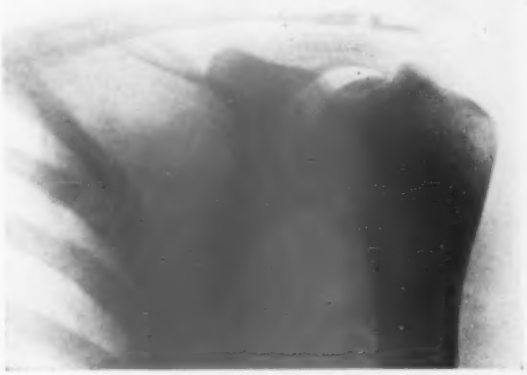

FIG. 2. Case 1. Conventional exposure of left shoulder shows the typical appearance of osteochondritis dissecans with formation of loose bodies.

The purpose of this paper is to add another case of bone infarcts in a caisson worker to the rapidly growing literature on this subject,[2,5,10,11] and to stress, by 4 additional case reports, the relative frequency of bone infarcts occurring in individuals who have not been exposed to compressed air. While histologic proof is lacking in these cases, their roentgenographic features are quite similar to cases[5,6,9] wherein biopsy and autopsy studies were made.

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FIG. 3. Case 1. The right shoulder presents even greater fragmentation of the humeral articular surface, incident to the infarct which extends down the proximal third of the shaft.

FIG. 4. Case 1. Dense calcareous deposit in left intertrochanteric area, probably represents calcification of old necrotic infarct.

FIG. 5. Case 1. Lateral view of knees shows faint calcareous remnants in the medullary portions of each femur.

REPORT OF CASES

Case 1. *Multiple bone infarcts in a caisson worker.* I. J., colored male, was hospitalized at the Walter Reed General Hospital at the age of thirty-seven, in 1932, for pharyngitis, acute; bronchitis, chronic; arthritis, left shoulder and syphilis, tertiary; in 1936, in the Veterans' Administrative Facility, Wadsworth, Kansas, for arthritis, degenerative, shoulders; and in 1937–1938, in the Veterans' Administrative Facility, Batavia, New York, for arthritis of the shoulders.

The history included the usual childhood diseases, influenza in 1917, followed by chronic bronchitis, "rheumatism" in the lower extremities since 1924, and in the shoulders since 1930. There was also a history of gonorrhea and a penile sore in 1911. Syphilis was, however, diagnosed only in the first hospitalization; the blood Wassermann and spinal fluid reactions were negative but the Kahn reaction was suggestive positive.

Patient gave his occupation as "sand hog," working in various construction projects throughout the country since about 1924. He denied, however, any history of "bends."

The chief complaint, at the time of his last hospitalization, was pain and limitation of motion of the shoulders; the left dated to 1930, the right to about 1933.

On examination, the only positive findings of significance were arthritic; the shoulders presented less than 50 per cent motion, with considerable crepitus and pain on forceful manipulation.

Fig. 6. Case 1. Anteroposterior view of knees. The infarcts do not extend into the epiphysis; the articular surfaces are smooth.

The cardiovascular system was reported normal in each hospitalization.

The blood counts and urinalyses were essentially normal.

Only the roentgenograms from the last hospitalization were available for study, but the reports from the other hospitalizations indicated the findings had not changed materially. Each shoulder presented a similar appearance, with irregularlity of the articular surface, loose body formation, and irregular, mottled densities extending down the medullary areas in the proximal third of the shaft, which were interpreted as old bone infarcts. The film of the pelvis revealed an interesting area of uniform density measuring 3×4 cm. in the intertro-

chanteric area of the left femur, which, in the light of the other findings, undoubtedly represents calcification of an old infarct. The femoral heads were not remarkable. The knees revealed a faint mottled calcareous deposit in the medullary portions of each femoral metaphysis, indicative of ancient, almost completely absorbed infarction.

It is tempting to speculate on the relation of findings in the lower femurs to the "rheumatism" complained of in the lower extremities. Apparently this complaint developed about the same time the patient engaged in compressed air work. Since no particular complaint was directed to the lower extremities in the last hospitalization, the question arises if, with replacement of necrotic bone by viable tissue, there was an associated amelioration of symptoms.

Case 11. *Multiple bone infarcts of undetermined etiology*. E. S., colored male, aged forty-three, was hospitalized in 1938, at the Veterans' Administration Facility hospital, Washington, D. C., for treatment of pain and chronic discharge from the left foot and ankle. Patient had served as mess attendant in the Navy; shortly following his discharge, he developed blisters over each foot and leg which healed slowly and recurred frequently. During the preceding year, the blisters on the left foot had developed into chronic discharging sinuses.

The family history was irrelevant. Past diseases were measles, gonorrhea, malaria and pneumonia. Prewar occupation: waiter and porter. Postwar occupation: messenger and paper hanger. No history of exposure to compressed air.

On examination, patient was well nourished

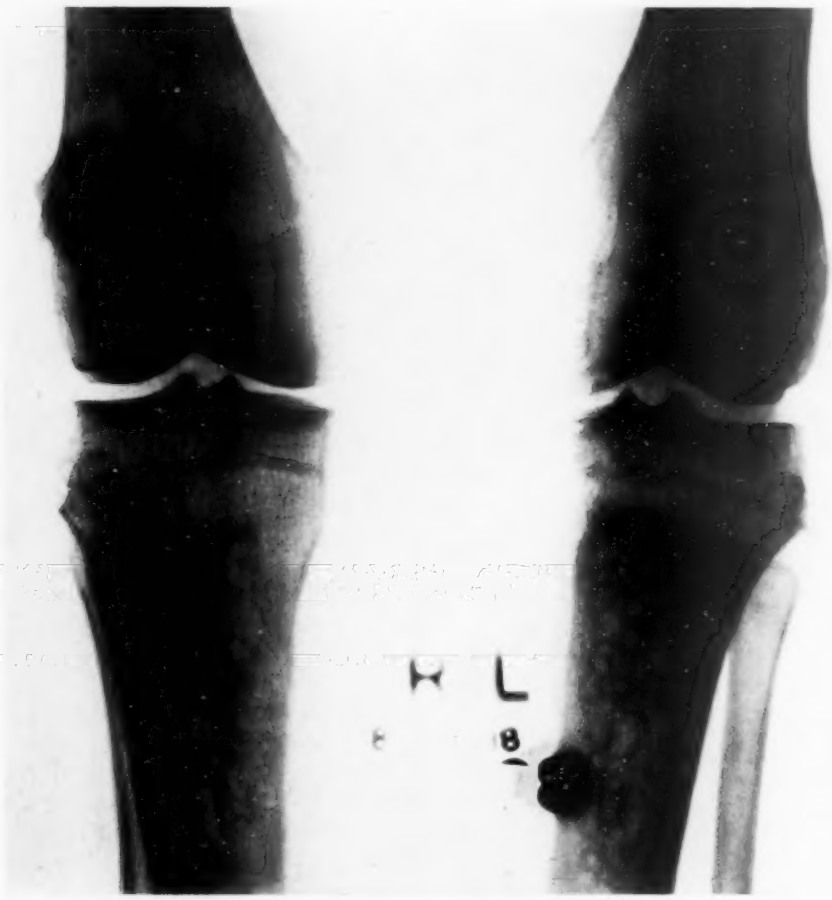

Fig. 7. Case 11. Anteroposterior view of knees. Small circinate calcific remnants in medullary tibial metaphyses.

and developed. The legs presented numerous scars on both legs from ulcers, with a recently healed ulcer on the right lower leg. Deep chronic ulcerations were present on the plantar aspect of the left great toe, the left instep and ankle. The examination further revealed marked sclerosis of the radial vessels and a hypertension of 180/110.

Urinalysis and blood count were normal; the Wassermann and Kahn reactions were negative. Roentgenograms of the lower extremities revealed, in addition to osteomyelitis of the left great toe, multiple circinate calcific deposits within the upper medullary metaphysis of each tibia. These did not extend into the epiphyses, the lines of which were fairly distinct. Films of the remaining skeleton were negative.

Treatment consisted of amputation of the left great toe; the other ulcers healed incident to the bed rest.

The history of chronic recurrent ulcers of the legs speaks for circulatory impairment; could the marked arteriosclerosis have been the underlying cause of the bone infarcts, as well as the soft tissue pathology?

Case III. *Multiple infarction of bones of undetermined cause.* J. F., white, American male, aged fifty-four, was hospitalized in Veterans' Administration Facility, Lake City, Florida, from September, 1937, until his death in May, 1938. Patient complained of dependent edema and swelling of the abdomen, with loss of at least 30 pounds during the past year. There was also a longstanding complaint of pain in the right foot and knee, dating to an accident in January, 1920.

Fig. 8. Case II. Lateral view of knees. Here also the infarcts stop short of the epiphyseal line.

The family history was non-contributory. Except for the usual childhood diseases, patient has been in good health throughout. The occupational history records two years of war-time service as military police, and employment as highway engineer since. There was no history of compressed air work.

On examination, patient was well developed, but showed evidence of weight loss. The abdomen presented marked enlargement of the

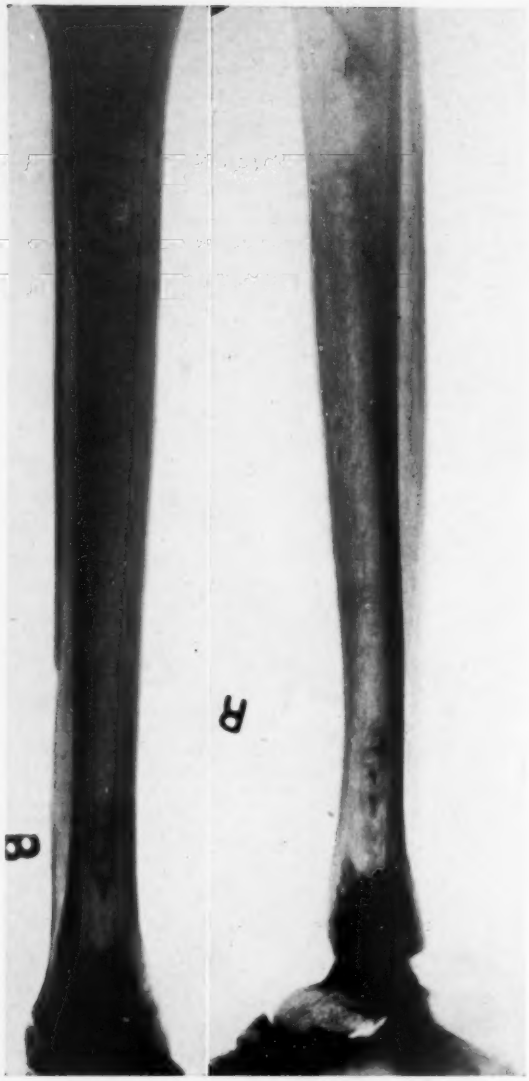

FIG. 9. Case III. Old infarcts in each metaphysis of the right tibia.

liver which was firm and non-tender. The spleen could not be felt. There was pitting edema of the feet and legs to the knees. The cardiovascular system was felt to be normal; the edema and enlarged liver were thought not to be of cardiovascular origin. The right knee presented a flexion deformity of about 20 degrees, with some swelling and tenderness. There was a hallux valgus on the right; the metatarsal heads were prominent and tender. It was felt that the edema and enlarged liver were due to portal cirrhosis, that the complaint referable to the right foot and knee were due to a weak foot, with strain.

Diabetes mellitus was also diagnosed when routine urinalysis revealed 4.5 per cent sugar, and the fasting blood sugar was found to be 222 mg. Some samples of urine contained albumin, but most did not. Bence-Jones albumin was not present. Repeated blood counts were normal. Blood nonprotein nitrogen, calcium and phosphorus yielded essentially normal findings. The Wassermann and Kahn reactions were negative. Basal metabolic rate was normal. Gastric contents were normal. Gastrointestinal series did not reveal any intrinsic abnormality of this tract. The gallbladder was faintly visualized in the cholecystogram.

Roentgenograms of the right knee revealed the well-defined, mottled calcifications within

FIG 10. Case III. The left tibia is similar to the right

the metaphyseal medullary portions of the femur and tibia, now recognized as due to infarcts. Roentgenographic study was then made of the entire skeleton. Similar infarcted areas were found in the corresponding areas of the left femur and tibia, and of the lower metaphysis of each tibia. Degenerative arthritic changes were present about each hip, without,

Fig 11. Case III. The right knee shows well-defined mottled calcific deposits in the metaphyses of the tibia and femur.

however, any apparent derangement of the femoral heads. There was fairly advanced sclerosis of the abdominal aorta and iliac vessels. No other roentgenologic findings of significance were encountered. The infarcted areas were roentgenographed again shortly before death; no change could be seen.

Clinically, the terminal symptoms consisted of an attack of pneumonia, from which he apparently recovered, and increasing pain, tenderness and swelling of the right knee. Unfortunately, no autopsy was obtained.

In view of the necropsy finding of a large Baker's cyst about the knee in a previously reported case[6] of bone infarcts, the question arises if an inflamed cyst may have produced the knee symptoms in this case.

Case IV. *Multiple bone infarcts of unknown cause.* J. K., Polish male, aged fifty-three, has been in the Veterans' Administration Facility, Bath, New York, since August, 1939, because of precordial pain on exertion and periods of edema and dyspnea.

The family history was irrelevant. Patient could recall no previous illness other than measles. He had been steadily employed as a cook and chef, before, during and since World War I. No history of exposure to compressed air. No injuries except for a fracture of the right hand during military service.

Patient was rather short and heavy. The pertinent findings were limited to the cardiovascular system, which revealed arteriosclerosis and moderate cardiac hypertrophy. There was no evidence of decompensation at the time of examination. The blood pressure was normal. The diagnosis was coronary arteriosclerotic heart disease, with cardiac enlargement and generalized arteriosclerosis.

The left knee was roentgenographed follow-

FIG. 12. Case III. The left knee presents similar appearance.

FIG. 13. Case IV. The left humerus shows a small medullary, solitary fleck of calcification in the middle third.

ing a fall. There was no evidence of injury, but mottled calcific deposits of old infarcts were found in the medullary portions of the distal third of the femur and proximal third of the tibia. Following roentgenographic survey of the remaining skeleton, similar lesions were encountered in the distal third of the right femur and a small isolated calcific deposit in the middle third of the left humerus. On requestioning the patient; no history could be elicited relative to any disturbance in the affected extremities.

Comment. It will be noted that the last three cases showed arteriosclerosis, while none was found in Case I, a caisson worker. It may eventually be established that bone infarcts result from arteriosclerosis, as well as from caisson disease. This is borne out by Phemister[9] who made histologic study of an infarct in the tibia from a case dying of arteriosclerosis and cardiac decompensation, without history of caisson disease. Chandler[1] has also demonstrated infarcts in the femoral heads following an obliterative

Fig. 14. Case IV. The proximal metaphysis of the left tibia presents an old medullary infarct. The tibial involvement was not bilateral in this case.

Fig. 15. Case IV. Remnant of old infarct in distal metaphysis of left femur.

Fig. 16. Case iv. Somewhat more extensive involvement of the right femur.

process of the supplying artery, where caisson disease was not a factor.

In the following case, however, neither arteriosclerosis nor history of caisson disease was elicited.

Case v. *Infarcts of humerus of unknown cause.* L. T., aged forty-three, white American male, was admitted to the Veterans' Administration Facility, Bath, New York, October, 1940, complaining of pain in each shoulder of about fifteen years' duration. The "lameness" was first noticed in the right shoulder; during the past five years the pain has shifted from one shoulder to the other. For one week prior to admission, excruciating pain was present in the left shoulder; this was the only attack of sufficient severity to completely incapacitate the patient.

The past history was remarkable in that patient could not recall any incapacitating illness, either during childhood or adult life prior to present disability. The only history of injury related to several dislocations of the right shoulder before and since onset of present disability. Except for a tonsillectomy about 1923 because of perennial sore throats, there had been no operations.

Patient's one and only occupation was cook. He had never been exposed to compressed air or had "the bends."

The only physical findings of significance were in the left shoulder which showed considerable painful limitation of motion, necessitating assistance with clothes. Tenderness was elicited over the subdeltoid bursa, but there was no local heat or swelling. There were no objective findings in the right shoulder. The cardiovascular system was normal except for mild varicosities of each leg.

The laboratory studies were non-contributory; blood count, urinalysis and basal metabolic rate were normal; the Wassermann and Kahn reactions were negative.

Roentgenograms of shoulders showed calcification about the spinatus tendons on the left and a "compact island" within the left humeral head. The right shoulder revealed a mottled marginal, irregular, non-reticulation defect in the humeral metaphysis, resembling old infarct. A roentgenologic survey of the remaining skeleton for additional lesions was negative.

Fig. 17. Case v. Calcification about spinatus tendons on left. Note "compact island" in humeral head.

Fig. 18. Case v. The right shoulder shows the rather typical appearance of old infarction in the humeral metaphysis. The articular surfaces are smooth.

Partial relief from pain was obtained following irrigation of the left subdeltoid bursa.

In view of the tendency to symmetrical distribution of these lesions, it is felt that the compact island in the right humerus probably represents a small remnant of an old infarct, similar to the small, solitary lesion in the humerus of Case iv. Since the right shoulder was first to give rise to symptoms, the smaller lesion here may indicate greater resorption of the infarct.

SUMMARY

1. The roentgenographic features of infarcts of the long bones are discussed.

2. Five cases showing multiple infarcts of bone are reported; one was a caisson worker, three had never been exposed to compressed air, but presented arteriosclerosis; in one case neither a history of caisson disease nor evidence of arteriosclerosis was elicited.

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Vol. 47, No. 3

COLON STUDIES

VIII. THE DIAPHRAGMATIC FLEXURE*

By JOHN L. KANTOR, M.D.
NEW YORK, NEW YORK

I. INTRODUCTION

IN THIS communication the term "diaphragmatic flexure" is used to describe an anatomical condition in which the splenic flexure is located directly under the left diaphragm.

Relatively little has appeared in the literature on the splenic flexure as such. For example, the heading "splenic flexure" is entirely missing in both the *Index Catalogue of the Library of The Surgeon General's Office* (Army Medical Library) and the *Quarterly Cumulative Index Medicus*. Except for an early Russian article[19] inaccessible to American readers, there is, as far as I can find, only one paper entirely devoted to the splenic flexure, namely the Paris Thesis of Joseph Cohn[6] of 1920. However, as early as 1904, Rieder[22] described gas in the colonic flexures, and in 1914 Schwarz[26] in his classic book on the clinical roentgen diagnosis of the colon was apparently the first to recognize the existence of the diaphragmatic flexure, inasmuch as he says "The gas-filled colon may reach above the spleen and under the diaphragm." In 1905 Payr[18] described chronic colonic obstruction due to inflammatory adhesions involving the ascending and descending limbs of the flexure, and since that time this condition has been known in the German literature as Payr's disease, and its rôle in "intestinal pneumatosis" is often mentioned by German writers.

In 1912 Roemheld[24] described the "gastrocardiac symptom complex," a condition in which indigestion, precordial distress, and cardiac symptoms were traced to the abnormal accumulation of gas under the left diaphragm either in the stomach or in the colon, due to aerophagia, colitis, chronic intestinal atony or Payr's disease. In 1933 Roemheld's son[25] discussed the gastrocardiac symptom complex accompanying the high diaphragm following left-sided phrenic exeresis, and in a paper on displacement of the gastrointestinal tract following the same operation, Rickers[21] published some films showing the stomach and splenic flexure located immediately under the elevated left diaphragm.

The French literature has been centered about the concept of "aérocolie." This was apparently first described by Loeper and Esmonet[15] in a paper on localized pneumatoses of the colon in 1913, and was considerably elaborated in Cohn's thesis in which he discussed gas at the splenic flexure as causing pain in the chest and meteorism, both symptoms being relieved by the passage of flatus per rectum. In 1921 Ramond and Borrien[20] described the digestive, circuculatory and respiratory symptoms of "aérocolie" of the splenic flexure. The concept of colitis localized to the splenic flexure was developed in the book on the colitides by Chiray, Lardennois and Baumann[4] published in 1934, and "aérocolie" of the splenic flexure in cases of redundant colon was treated in considerable detail by Chiray, Lomon and Wahl[5] in their classic work on the dolichocolon published in 1931.

The English literature on this subject is scant. A good discussion is included in Buckstein's book[2] on functional disorders of the colon.

At this point a brief review of the embryology and anatomy of the normal

* This is the eighth of a series of articles. I. The redundant colon, AM. J. ROENTGENOL. & RAD. THERAPY, 1924, *12*, 414–430; II. The low cecum. *Ibid.*, 1925, *14*, 207–215; III. The clinical significance of ileal stasis; its association with colitis. *Ibid.*, 1926, *16*, 1–9; IV. The roentgen diagnosis of colitis (the irritable colon). *Ibid.*, 1927, *17*, 405–416; V. The high cecum. *Ibid.*, 1928, *19*, 101–111; VI. Cecal stasis; its clinical significance and relation to proximal colon stasis. *Ibid.*, 1930, *24*, 1–20; VII. Variations in fixation of the cecocolon; their clinical significance. *Ibid.*, 1934, *31*, 751–765.

splenic flexure may be in order. The splenic flexure is laid down in the fetus at about the sixth week. It is quickly fixed, like the duodenojejunal flexure, and constitutes with the latter the earliest fixed points of the intestine. In the fetus, and later in the infant the flexure is placed lower than in the adult because of the great development of the left lobe of the liver.[6] In the adult, "the left colic or splenic flexure is situated at the junction of the transverse and descending parts of the colon, and is in relation with the lower end of the spleen and the tail of the pancreas . . . and is attached to the diaphragm opposite the tenth and eleventh ribs by a peritoneal fold named the phrenocolic ligament which assists in supporting the lower end of the spleen" (Gray).[7] According to Buy,[3] the phrenocolic ligament is 2 to 3 cm. ($\frac{3}{4}$ to $1\frac{1}{4}$ inches) long.

The above descriptions all imply that the flexura sinistra coli is in close proximity to the spleen, usually reaching to its tip or in some cases extending further upward along its inner (visceral) surface, and this is indeed the usual or normal position of the splenic flexure and the reason for its name. However, the fact that this flexure may in some individuals reach to, or actually course along under the left diaphragm, although occasionally mentioned, is not stressed nor is its significance explained either in books on anatomy or in those on the roentgenology of the digestive tract. A more detailed description of the diaphragmatic flexure will be attempted later in this paper.

Having for some years been accumulating data on this anomaly, I have come to the conclusion that it possesses much more than academic interest. It is now proposed not only to report the incidence of the diaphragmatic flexure but to discuss its clinical significance, and stress its practical importance. In the early phases of the compilations on which this report is based, I was assisted by Dr. Earl D. DuBois of Portland, Oregon, and I desire here to express my appreciation of his generous contribution of time and energy.

II. MATERIAL, METHODS, CRITERIA, TECHNIQUE

The material used for this investigation is similar to that employed in the previous studies of this series. It consists of an unselected series of private patients, most of whom had a routine gastrointestinal study including a history, physical examination, test meal, and roentgen examination. The roentgen study included the daily observation of a progress meal until the colon was empty, or until the examination was discontinued on account of packing in the rectum, as well as an opaque enema with films taken before and after evacuation.

For the purpose of this study a total of 1,478 consecutive cases was reviewed. Of this group only 996 presented data complete enough to be of value. Following the procedure employed in previous studies, two lists were made up, one containing the diaphragmatic flexure cases, the other the non-diaphragmatic flexure cases. The first 200 cases of the latter were utilized as the "control group" and were subjected to the same critical analysis as were the diaphragmatic flexure cases.

The criteria of a diaphragmatic flexure were established arbitrarily as follows: The tip of the splenic flexure must lie one-half inch (1.25 cm.) or less from the diaphragm when measured directly vertically on any film taken in the prone posture following either a barium meal or an opaque enema. The diaphragmatic flexure may be considered *fixed* when the distance between bowel and diaphragm remains one-half inch (1.25 cm.) or less on every film following the barium meal and opaque enema, including the film after evacuation of the enema (Figs. 4, 5 and 6). Otherwise, the flexure is considered movable.

For the study of the diaphragmatic flexure the use of 14 by 17 inch films is essential. Even these may prove too small in the case of opaque enemas where the spread between the diaphragm and the rectum may be greater than can be covered in a single negative, especially in large subjects. In such cases it may be necessary to use

Fig. 2. Diphragmatic flexure. Opaque enema, prone, showing flexure running along diaphragm to right. Woman, aged seventy-two, complaining of heart burn, regurgitation, long-standing constipation, chest pressure, and gas. No cardiac symptoms. Blood pressure and heart action normal, systolic murmur at base.

two 14 by 17 inch films, one portraying the details of the diaphragm, the other those of the rectum. Although both progress meal and opaque enema studies are desirable for

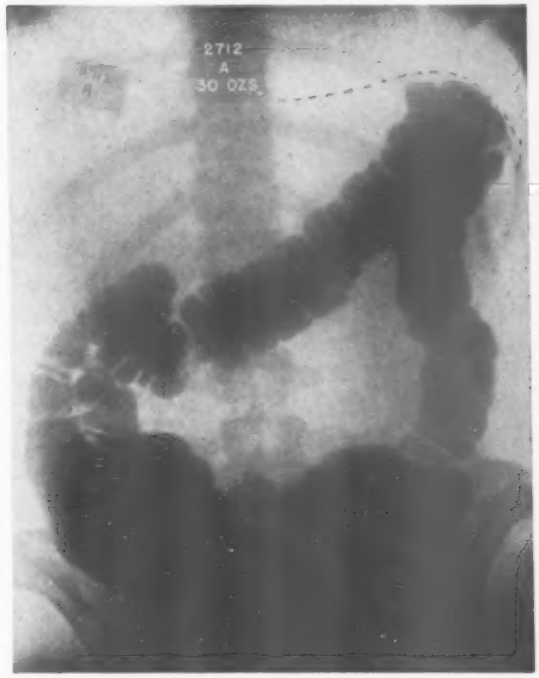

Fig. 1. Diaphragmatic flexure. Opaque enema prone, showing flexure touching diaphragm laterally. Woman, aged forty-four, complaining of heart burn, constipation, gas pressure, and epigastric pain. Cholecystography showed one small gallstone.

completeness or for research investigations, it is believed that films taken before and after the evacuation of an opaque enema would suffice for a clinical diagnosis in most cases.

Fig. 3. Diaphragmatic flexure with moderate eventration. Film taken immediately after meal, erect, showing flexure outlined with gas. Woman, aged forty, complaining of chest pressure, flatulence, and constipation, but no heart burn. Note downward displacement of stomach.

III. DESCRIPTION OF THE DIAPHRAGMATIC FLEXURE

The diaphragmatic flexure may appear to touch the diaphragm at one point, sometimes quite laterally (Fig. 1), or else it may run along the diaphragm for a variable dis-

Fig. 4. Diaphragmatic flexure, fixed. Film taken seventy-two hours after meal, prone, showing flexure outlined partly by gas, partly by barium. Note iliac kink (redundancy). Woman, aged forty-two, complaining of moderate heart burn especially on bending, much distention, some constipation and abdominal pain. Same case as Figures 5 and 6.

tance to the right (Fig. 2). The latter arrangement is especially likely when the transverse colon, or its distal portion, is unusually high in position. Occasionally the diaphragmatic flexure is itself redundant and may exhibit several distinct loops. In this case its contents are considerably increased so that it may retain a large part of the opaque enema.

The relation of the diaphragmatic flexure to the adjacent organs is correspondingly altered from the normal. The stomach may be displaced a varying distance to the right or downward and forward in its entirety (Fig. 3), or it may assume a cascade ("cup and spill") configuration by virtue of the fixation of its cardiac portion. The spleen, instead of lying above the colon, occupies a position either entirely lateral to the bowel, or it may be displaced below, as well as to the left of, the tip of the diaphragmatic flexure.

As already mentioned, the diagnosis of diaphragmatic flexure is readily made by both the barium meal and opaque enema studies. In observing the appearance of a *fixed* diaphragmatic flexure during the progress of a barium meal, it will be found at times entirely filled by gas (Fig. 3), at others outlined by barium or by a combination of both types of shadows (Fig. 4). When both barium and gas are present the gas is usually on top, the barium appearing in the form of separate clumps or scybala at a lower level. In practically all cases, however, the opaque enema fills the flexure completely right up to the diaphragm (Figs. 1, 2, 5 and 6).

The association of the diaphragmatic flexure with other neighboring anomalies is of interest. The concomitant presence of a kinked or redundant colon is frequent and probably clinically important (Figs. 4 and 5). This will be discussed later. Association with the more rare condition of eventration of the left diaphragm was encountered three times in the present series. Two of these cases showed symptoms that we have

Fig. 5. Diaphragmatic flexure, fixed. Opaque enema prone, showing flexure under diaphragm, and kink in iliac portion. Same case as Figures 4 and 6.

learned to associate with the diaphragmatic flexure. Especially interesting was a patient seen through the courtesy of Dr. Victor Meltzer. The woman was sixty years old and for years had been regarded as a "neurotic" with attacks of indigestion and pains of anginal nature. She had long-standing constipation, cathartic habit, and suffered from occasional regurgitation as well as from heart burn after practically every meal. The patient was most confortable when bolstered up in a semirecumbent position. Roentgen examination showed that the left diaphragm was situated half way up in the thorax. Both the stomach, which was inverted, and practically the entire colon, were found to occupy the left chest cavity (Fig. 7).

Eventration of the left diaphragm is artificially produced by the operation of left phrenic exeresis which is now being performed for immobilization of the lung in pulmonary tuberculosis. No such cases are included in this series and the interested reader will have to consult the current literature on tuberculosis for further information. Hiatus hernia should also be mentioned in this connection. In such cases not only the stomach, but also the colon may prolapse into the chest cavity through the esophageal foramen. Symptoms similar to those produced by the diaphragmatic flexure are not uncommon. Heart burn is present in 40 to 50 per cent of the cases, and substernal distress, occasionally anginal in character, may occur even more often.[16,17,23] A less frequent but also related condition which may occasionally involve the splenic flexure is hernia of the left diaphragm. This is traumatic in nature and may result from battle injuries. A brief discussion of cases encountered in World War I will be found in Cohn's thesis.

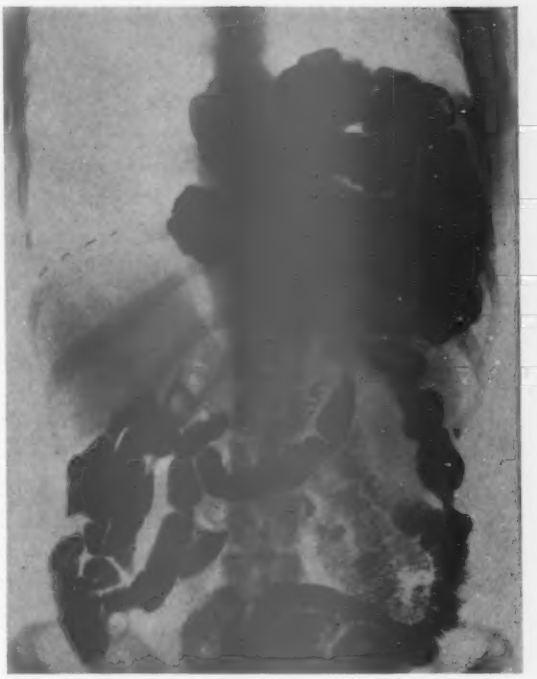

Fig. 7. Diaphragmatic flexure with marked eventration. Film taken six hours after meal, prone, showing almost entire colon in left chest. Woman, aged sixty, long regarded as "neurotic" and probable "cardiac," complaining of heart burn, regurgitation, and anginal pains. Symptoms relieved by semirecumbent posture.

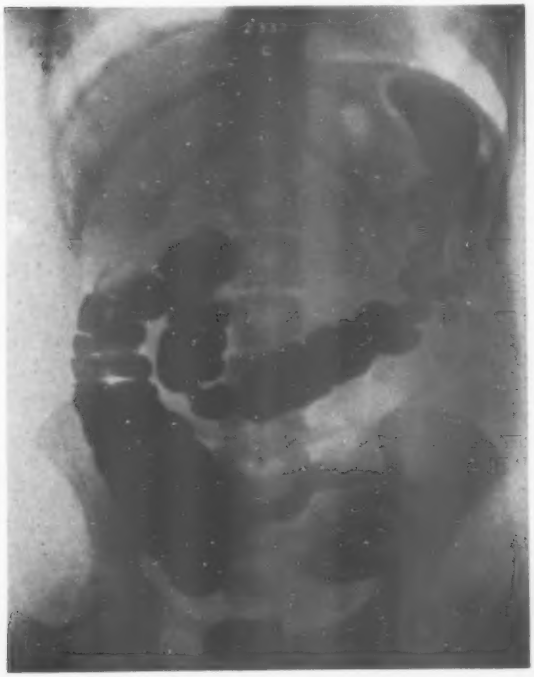

Fig. 6. Diphragmatic flexure, fixed. Opaque enema, prone, after bowels had moved ("post evacuation film"), showing flexure tip still fixed under left diaphragm. Same case as Figures 4 and 5.

IV. INCIDENCE (TABLE I)

General Incidence. In the 996 cases in which the location of the splenic flexure

TABLE I

DIAPHRAGMATIC FLEXURE

	Cases	Per Cent
Incidence		
General, in 996 roentgenographed patients	157	15
Sex:		
Females	87	55
Males	70	45
Habitus:		
Sthenics	47	30
Asthenics	20	12
Fixation:		
Fixed	62	42
Mobile	84	57
Associated redundant colon (general incidence 18%)	46	29
Clinical Features		
Heart burn	73	46
Chest distress	32	20
Constipation	105	64
Flatulence	79	50

was satisfactorily studied, a diaphragmatic flexure was present 157 times, giving an incidence of slightly over 15 per cent. According to these figures the anomaly is not rare, its frequency being almost that of the two most common anomalies of the colon, redundancy and low cecum.

Fixation. Of the 157 diaphragmatic flexure cases 146 proved available for the study of fixation. In the latter group fixation occurred in 62 cases, or in 42 per cent. Mobility was diagnosed in the remaining 84 cases, or in 57 per cent.

Sex. Males represented 45 per cent of the patients with diaphragmatic flexure and 42 per cent of the control group. There is thus no significant difference in sex incidence.

Habitus. The sthenic habitus was encountered in 47 cases, or in 30 per cent of the 157 diaphragmatic flexure patients, but it was present in only 39 cases, or in 19 per cent of the control group. Conversely, asthenics occurred in 20 cases, or in 12 per cent of the diaphragmatic flexure patients, but they constituted 66 cases, or 33 per cent of the control group. In other words, subjects with diaphragmatic flexures are much more likely to be stocky in build than are those with normal splenic flexures.

Association with Redundant Colon. In the 157 cases of diaphragmatic flexure, redundant colon occurred in 46, an incidence of 29 per cent. This figure is substantially higher than the general incidence of redundant colon as previously established in an unselected series of 1,850 roentgenographed patients, namely 18 per cent.[12] It is over twice as high as in the control group, in which redundant colon occurred in but 13 per cent. The association of these two anomalies, increasing as it does the tendency to constipation, is probably of clinical significance.

V. CLINICAL MANIFESTATIONS AND THEIR SIGNIFICANCE (TABLE I)

General. In previous communications it has been pointed out that not all anomalies cause symptoms all of the time. In fact it is often necessary for several conditions to coexist before clinical manifestations are likely to occur.[12] The diaphragmatic flexure offers no exception to this general rule. The several factors about to be described produce their symptoms by exerting pressure on the adjacent organs, particularly the heart and the stomach. Perhaps the most important condition requisite for this effect is an associated abnormality of colonic function which results in distention of the diaphragmatic flexure by feces or particularly by gas. When gas is present, whether it represents the residues of swallowed air or the results of putrefaction or fermentation, the spontaneous efforts of the sufferer may often increase the underlying difficulty. Thus the patient may try to "bring up" the gas in the diaphragmatic flexure by repeated attempts at belching, but as elsewhere described,[10,11] the net result of such forced belching is really air swallowing with increase in the intestinal gas content and its further pocketing under the left diaphragm. Another mistaken procedure is the use of cathartics, enemas, and

irrigations which, by irritating the mucosa, still further interfere with gas absorption.

A second condition favoring the production of symptoms is the prevention of free gas expulsion and its retention or imprisonment at the diaphragmatic flexure. This is greatly favored by distal colonic spasm as in most cases of constipation, by redundancy of the distal (pelvic) colon, and by rectal stasis (dyschezia). Even an acute attack of piles may "blow up" the colon.

A third possible requirement is that the adjacent viscera must actually receive the brunt of the increased colonic pressure. This result, for example, would be favored by perigastric adhesions or by organic cardiac involvement. On the other hand, it is conceivable that under certain favorable circumstances the heart or the stomach might escape such pressure and that these usually vocal organs would then remain silent. Thus in a few of our most marked instances of diaphragmatic flexure it was observed that heart burn was absent. Here a distinct displacement of the stomach to the right or downward was also noted, suggesting that, by virtue of this free mobility the required regurgitation of gastric contents into the esophagus was prevented. Similarly, a slight rotation of the heart or increased mobility of the mediastinum may be sufficient to forestall the appearance of cardiac symptoms.

In short, the diaphragmatic flexure is most likely to cause symptoms when gas is present, when its escape is hindered from below, and when the effect of its pressure on adjacent organs is increased by their position, fixation, or previous affection by organic disease.

Heart Burn. Although several theories have been invoked to explain the ultimate mechanism of heart burn (Hertz,[8] Alvarez,[1] Jones[9]), it is still a fact commonly observed by many sufferers that a prominent *immediate* cause of this symptom is the spilling or regurgitation of gastric contents into the lower portion of a sensitive esophagus. This spilling occurs especially when the gastric contents are most fluid and the mechanical factors most favorable. Thus heart burn is produced or exaggerated whenever the level of the cardia is brought below the surface of the stomach contents by postural changes such as reclining or bending to the right side, or bending forward; or whenever the intragastric pressure is increased sufficiently to eject the contents into the esophagus regardless of posture, as in hiccups, or in excessive laughter; or by the external pressure of tight belts, corsets, or binders. One of my patients, a woman physician, reports that her guests often say after dinner, "Don't give me a soft low chair but a straight hard chair on account of my heart burn," and she has known women to leave good seats to stand in a theater, for the same reason. The severe heart burn of pregnancy is well known and its increase in the last six months of gestation is probably due to nothing else than progressive intra-abdominal pressure.

The intimate association of heart burn with diaphragmatic flexure is indicated by the following statistics: Heart burn occurred in 73 cases, or in 46 per cent, of our diaphragmatic flexure patients and in only 19 per cent of the control group. In other words, it is fully two and a half times more common in patients with diaphragmatic, than in those with normally placed, splenic flexures.

It was repeatedly revealed by the clinical histories of the more observant patients that their heart burn was always worse when they were constipated, and conversely that it was relieved or absent when the bowels moved normally and gas was passed freely by rectum. The relationship between heart burn and the state of filling of the splenic flexure was impressively confirmed during the examination of a patient by means of a barium enema. This was administered under roentgenoscopic control at a time when no spontaneous heart burn was present. As soon as the enema fluid reached and distended the diaphragmatic flexure the patient complained of heart burn similar to that described in the original history. When the enema can was lowered to the floor the diaphragmatic flexure was evacuated with relief of the pyrosis.

The entire experiment was then repeated with the same result.

A statistical survey of the relation of constipation to the position of the splenic flexure showed that constipation occurred in 105 cases, or in 64 per cent, of the diaphragmatic flexure group, but only in 43 per cent of the control group. Flatulence was also slightly more frequent in the presence of diaphragmatic flexure, the incidence being 50 per cent as contrasted with 43 per cent in the control group. From this evidence it may be concluded that heart burn is very likely to occur in the presence of a diaphragmatic flexure associated with constipation. The mechanical sequences involved may be summarized as follows: The gas imprisoned in the flexure produces a gas pocket which presses on the stomach. This pressure causes regurgitation of gastric contents into the sensitized esophagus resulting in heart burn.

Apparently the above facts have escaped the attention of previous observers. At least, although most of the authorities quoted earlier in this paper mention the fact that gas in the splenic flexure may cause pressure upon, or even dislocation of, the stomach, and describe the effects, they never mention heart burn among the resulting symptoms. The only reference to this possibility is that by Alvarez[1] who says in passing that heart burn may be relieved by a bowel movement and that a distended transverse or splenic flexure may cause this type of distress. Since the colonic nature of heart burn has heretofore been largely, if not entirely, overlooked it is not surprising that an effective form of therapy has been missed in such cases. The details of treatment will be taken up in a later section.

Chest Distress. Another prominent symptom associated with the diaphragmatic flexure is chest distress. It is often described by patients as a precordial pressure or pain and is occasionally associated with radiation down the left arm in typical anginal fashion. In some patients common cardiac symptoms are noted, such as palpitation, extrasystole, and dyspnea especially on exertion and after eating. It is worth noting that these symptoms occur both in the presence and in the absence of organic heart disease. As in the case of heart burn some of our patients have observed complete relief of chest distress after a bowel movement. Here also, in a man with coronary distress, we actually succeeded in reproducing his chest pains by filling his colon with the standard opaque enema.

Analysis of our clinical material showed that chest distress occurred in 32 cases, or in 20 per cent, of the diaphragmatic flexure group, whereas it was noted in only 8 per cent of the control group. Organic heart disease was present in 11 cases, or in 34 per cent, of the patients with chest distress. In cases of diaphragmatic flexure associated with constipation, the incidence of chest distress rose to 27 per cent, and in cases associated with redundant colon the incidence of chest distress was increased to 28 per cent.

In contrast to their silence concerning heart burn resulting from gas accumulation under the left diaphragm, most previous writers have described in great detail the chest symptoms resulting from this condition. One obtains the impression that the rôle assigned to the stomach bubble is exaggerated by some authors since the swallowed air is usually belched readily except in the case of gastric pneumatosis with retrograde cardiospasm. This condition, though it certainly favors intestinal flatulence, occurred in only 1.7 per cent of our cases in a previously reported series.[14] Hence, its rôle is probably much less important than that of the diaphragmatic flexure. The development of the "gastrocardial symptom complex" was observed by Roemheld in about 12 per cent of patients in whom left phrenic exeresis was performed for the treatment of pulmonary tuberculosis. The French writers attribute arrhythmia, palpitation, sense of arrested heart action, mild syncope, and pseudoangina to "blocked aerocoly." No mention, however, is made of the existence of diaphragmatic flexure or of its rôle in predisposing to the occurrence of these symptoms.

VI. THERAPY

If the findings reported in this paper are correct, it must follow that an effective way to obtain relief from heart burn and chest distress in the presence of diaphragmatic flexure is by treating the colon. This form of indirect therapy is apparently a new concept in the management of heart burn although it has been described in more or less detail in the treatment of chest symptoms resulting from colonic flatulence.

In order to avoid misunderstanding, it should be stated at the outset that the procedures about to be described are to be employed in addition to, rather than in place of, other dietary, medicinal, or hygienic measures for the relief of heart burn. Similarly, the treatment here outlined is obviously not meant to replace the necessary appropriate special therapy for either organic or functional disease of the cardiovascular system.

The secret of successful therapy in cases of diaphragmatic flexure, as in all cases of non-organic disease of the large intestine, is the restoration of normal colon function. This has been explained elsewhere,[11] but may be briefly recapitualted under the heading of the three R's as follows:

1. *Reassurance.* The patient's condition must be explained to him so that he can have a correct understanding of the probable relation between his symptoms and the presence of a diaphragmatic flexure in a decompensated colon. False notions, such as fear of cardiac disease where none exists, should be corrected.

2. *Relaxation.* Peace of mind should be should be aided by explanations such as are outlined above. In addition, equanimity should be cultivated as much as possible considering the personality of the patient. Rest of the body should be provided especially by securing adequate sleep with supplementary periods of bed rest if needed, such as at week-ends, and during menstrual periods where necessary. The use of appropriate sedatives and somnifacients is often beneficial. For the relaxation of colonic musculature and the control of spasm, belladonna in the form of the tincture is still unsurpassed. The drug should be pushed to physiologic limits where needed.

3. *Re-education.* This involves the instruction of the patient in the essentials of colonic physiology. The withdrawal of vicious bowel habits such as the use of cathartics, enemas, and irrigations, is essential as they all tend to increase colonic irritability. The drinking of hot water immediately on arising, and the consumption of sufficient fruit fiber in the daily diet[13] are among the simple hygienic procedures of most value. For artificial bulk production the carefully graded addition of water-absorbing vegetable gums and powder, or of mineral oil or oil agar mixtures, is indicated. For the tendency to rectal impaction the use of oil injections or of soothing and lubricating (cocoa butter) suppositories is recommended. Anything that restores spontaneous and regular bowel action, and promotes free gas passage, helps prevent the development of pressure factors at the diaphragmatic flexure.

For immediate effect on the diaphragmatic flexure the control of posture is desirable. Reclining on the left side tends to prevent the regurgitation of irritating gastric contents into the esophagus and aids the expulsion of gas per rectum. In some cases a special bolster may be employed in order to insure the assumption of the correct posture while sleeping. Activities involving body bending after meals, and the wearing of tight bands, belts, and corsets, should be avoided.

In cases of high left diaphragm due to eventration, and certainly following the operation of left phrenic exeresis, breathing exercises may be employed as recommended by Roemheld. These involve systematic diaphragmatic breathing performed two or three times a day, at first lying, then sitting, standing, and walking. Unilateral thoracic breathing may be practiced as follows: The patient sits on a chair, leans to the right and seizes the front leg of the chair with the right hand. He then lifts up the left arm and makes breathing motions with the left half of his chest.

SUMMARY

1. The term "diaphragmatic flexure" is suggested to describe a splenic flexure which is located directly under the left diaphragm.

2. The diagnosis is readily made by roentgen examination utilizing both barium meal and opaque enema.

3. The diaphragmatic flexure occurs in about 15 per cent of patients. It is fixed in a little less than half the cases, appears more frequently in sthenics than in asthenics, and is often associated with a redundant colon.

4. As with other anomalies the diaphragmatic flexure is most likely to cause symptoms when several conditions coexist to favor their development. Such factors are the presence of gas due to colonic malfunction, its imprisonment by interference with its escape below, and the effective transmission of the resulting pressure to adjacent organs.

5. The most important symptoms associated with the diaphragmatic flexure are heart burn, chest distress, and cardiac embarrassment. The colonic origin of heart burn has heretofore been apparently overlooked and is accordingly emphasized. Chest symptoms occur whether or not organic heart disease is present.

6. In order to be as completely effective as possible the treatment of symptoms associated with diaphragmatic flexure must include, in addition to other appropriate measures, the restoration of normal colon evacuation. The control of posture and the avoidance of external pressure are also important.

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PELVIMETRY BY THE PERFORATED PLATE METHOD

By SAMUEL G. HENDERSON, M.D.

From the Department of Radiology, Elizabeth Steel Magee Hospital

PITTSBURGH, PENNSYLVANIA

THE technique of accurately visualizing the pelvic inlet by roentgen examination was described by Thoms in 1922, and at the same time a method of determining the true conjugate diameter was presented.[4] In later papers[5,6,7] the same author proposed a more simple means of measuring the various diameters of the pelvic inlet, as well as the fronto-occipital diameter of the fetal skull. The plane of the true conjugate diameter is determined by external landmarks, and the patient is then so placed that this plane is parallel to the table top. Following exposure of a film in the anteroposterior diameter the patient is removed from the table. A lead plate perforated at intervals of 1 centimeter is so placed as to correspond to the position in space previously occupied by the plane of the true conjugate diameter and a flash exposure is made. This permits correction of the magnification on the film and determination of the true measurements. Also, by external palpation Thoms was able to locate the position of the forehead and occiput of the fetus in vertex presentations and measurement of the occipito-frontal diameter of the fetal skull could thus be made with a fair degree of accuracy. In still other papers, Thoms[8] and Thoms and Wilson[9] described a lead and iron rod with a centimeter scale notched on the edge of its upper third. This rod was placed posterior to the patient close to the intergluteal fold, and a lateral roentgenogram was made with the patient in the erect position. The lateral roentgenogram not only gave valuable information concerning the cephalopelvic relations and the anatomy of the maternal pelvis, but also furnished an easy means of measuring the true conjugate diameter. In a recent paper on this subject Thoms[10] explains the use of calibrated calipers, these being substituted for the grid and upright centimeter rod previously employed. He states that these calipers are corrected for various horizontal distances above the film using a standard target-film distance of 36 inches. Diameters of pelvic inlet, mid-plane and outlet can thus be measured.

In some patients, particularly obese individuals, there is difficulty in accurately determining the plane of the pelvic inlet by external landmarks and in addition many obstetricians feel the need of help from the roentgenologist more in the measurement of the outlet diameters than in those of the inlet. Therefore, in an effort to accurately determine the plane of the pelvic inlet so that it might be possible to place a film for the anteroposterior view parallel to this plane, and also, to find a simple and accurate method of measuring all the pelvic diameters, this study was inaugurated.

The necessary accessory equipment is shown in Figure 1. When this work was first begun a roentgen therapy table with a wooden top, 1 inch thick, was used. This thickness of wood was objectionable, and later a plain wooden table measuring 72 inches in length, 24 inches wide, and 36 inches in height was built. To facilitate the making of anteroposterior views, a center panel of bakelite measuring 20 by 24 inches was incorporated. Mounted on the side of the table adjacent to the bakelite panel is an upright frame of angle iron, so designed that a 14 by 17 inch cassette can be placed in it, perpendicular to the plane of the table top. In this frame the lower edge of the cassette rests 1 inch below the top of the bakelite panel. A groove in the frame formed by a flange is wide enough to accommodate both the cassette and a 14 by 17 inch wafer grid, the flange maintaining the grid and cassette in vertical position.

Attached by hinges to the underside of the table is a cassette holder consisting of a board measuring 16 by 18 inches, with a strip of wood molding at each of three sides,

the side next to the operator being left open for greater ease in placing and removing the cassette. The hinges are attached to the wooden table top at the foot end of the bakelite panel. At the opposite end a set screw device with a long threaded bolt holds the board at any desired angle.

Castors are used on the table legs to facilitate moving, and a locking device is included for the purpose of immobilizing the table when desired. In case a mobile roentgenographic unit is used, castors are unnecessary, but they are very useful when one is using the rail-mounted tube stand.

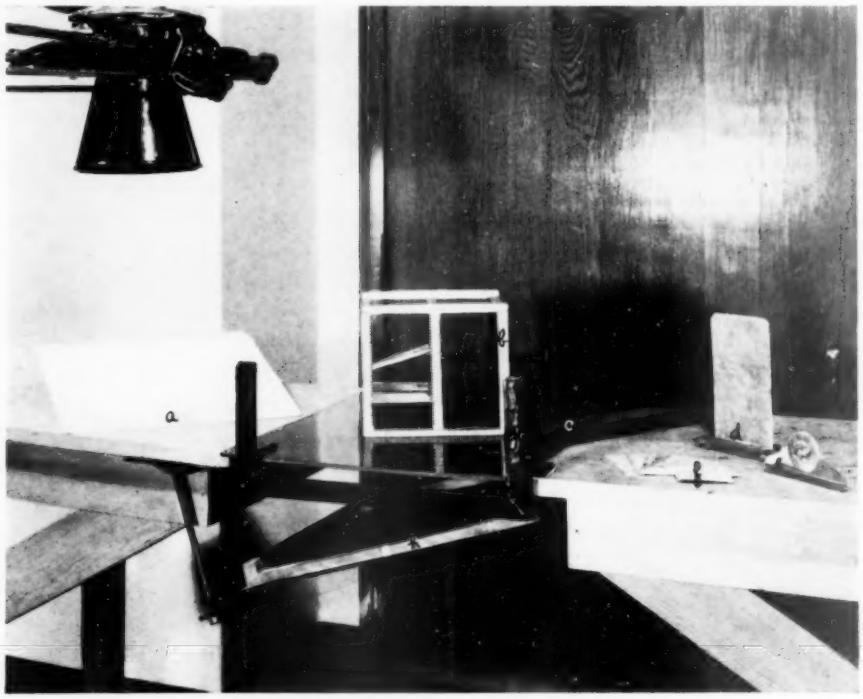

Fig. 1. Table and accessory equipment used in pelvimetry by the perforated plate method. *a*, Lysholm (wafer) grid; *b*, wooden frame with one movable and two stationary uprights; *c*, transparent ruler; *d*, upright centimeter-perforated steel plate; *e*, all-angle level; *f*, aluminum plates of various lengths, all perforated at 1 cm. intervals; *g*, angle iron attached to side of table; *h*, cassette holder beneath table.

In addition to this equipment, a steel plate, mounted in a wooden base and perforated at 1 cm. intervals is necessary. It should be noted here that the wooden base has a groove which allows the lower edge of the steel plate to be flush with the underside of the base and, consequently, when in use the edge of the steel plate rests upon the table top. Also, aluminum plates varying in length by 0.5 cm. gradations from 8 to 14 cm., each 1 mm. in thickness and 7 cm. in width, are used. The plate used in a particular case will depend upon the length of the true conjugate. These plates are perforated at 1 cm. intervals and are so designed that they may be placed at varying heights in the grooves of a wooden frame. This frame consists of a base, at each end of which a stationary wooden upright is attached at a right angle to the base. A third movable wooden upright of the same height as the first two is joined by means of a set screw to one of the stationary uprights. It is so designed that it may be moved by the set screw over the entire length of the frame between the stationary uprights. On either side a single wooden bar connects the upper ends of the stationary uprights for purpose of stability, and to serve as overhead tracks for the movable upright. One face of the

movable upright and the apposing face of one of the stationary uprights are grooved transversely at 0.5 cm. intervals, the grooves being designed to receive the above-mentioned perforated aluminum plates. Each groove is approximately 2 mm. in vertical diameter and 3.5 mm. deep, with 3 mm. vertical diameter of wood between grooves.

In conducting the roentgen examination two films are used, one for a direct lateral view and one for an anteroposterior projection, the patient being in the recumbent position on the table with the hips resting on the bakelite panel for both views. Following the technique suggested by Caldwell, Moloy and Swenson[2] a lumbosacral pad consisting of a rolled sheet about 2 inches in diameter is placed crosswise under the back at the level of the iliac crests. This helps to place the plane of the pelvic inlet in a position more nearly parallel with the table top. The patient lies as close as possible to the side of the table on which the cassette is placed in the upright frame of angle iron. This position is maintained until the examination is completed.

The perforated steel plate in its wooden base is now placed between the patient's legs, with one end of the plate, protected by a towel, resting against the vulva. The edge of the plate toward the patient's feet is in line with the lower end of the cassette. The plate must be parallel with the plane of the cassette, and it will then be noted that the plate is in the midline of the patient's body and, consequently, in the same line as the true conjugate.

The exposure factors to be used will, of course, depend upon the individual roentgenographic equipment. The lateral pelvis is measured at the level of the greater trochanters. Using full wave rectified equipment and par speed screens, for an individual measuring 33 cm. the following factors are used: 84 kv. (peak), 50 ma., .7 seconds, 36 inch distance, wafer stationary grid.

Following the exposure the patient is cautioned against moving, and the film is developed immediately. The wet film is then examined and the true conjugate diameter is determined at once by measuring the distance in centimeters from the posterior edge of the upper third of the symphysis pubis to the sacral promontory. Now, by placing the measuring stick on the shadow of the perforated plate and counting the number of perforations included in this measurement, the exact true conjugate diameter is found.

FIG. 2. Arrangement of patient, tube and film for examination in the lateral projection. Note vertical centimeter-perforated plate between legs.

In addition to the symphysis pubis and the sacral promontory there are visualized in the lateral view the shadows of the ischial spines, the ischial tuberosities and the sacrosciatic notch. Since the perforated steel plate rests directly upon the table top, the actual distance in centimeters of these visualized structures above the table top can be determined readily by counting the number of perforations. For instance, the symphysis pubis will be found in most cases to be about 14 cm. above the top of the table, the sacral promontory (varying with the inclination of the pelvic inlet) possibly 11 cm., the ischial spines perhaps 6 cm., with the ischial tuberosities usually about 5 cm.

If one proceeds as above to determine the actual true conjugate diameter and the heights of the symphysis pubis and sacral promontory above the top of the table, it is readily seen that we will know three parts of a proportion; that is, the true conjugate

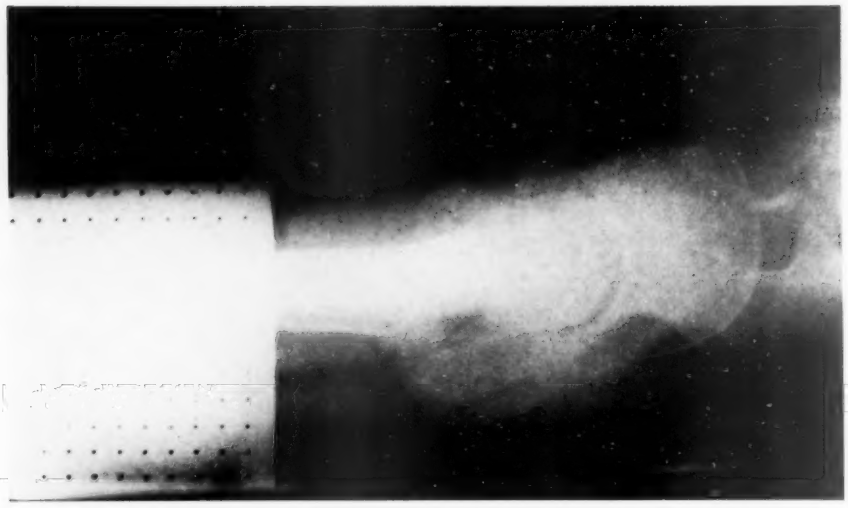

Fig. 3*a*. Lateral film of pelvis and erect centimeter-perforated plate.

diameter *A*, the difference in height between the symphysis pubis and sacral promontory *B*, and the over-all length of a 14 by 17 inch cassette *A'*, which is usually 45 cm. The fourth part of the proportion *B'* is the distance which one end of the film beneath the table (for the anteroposterior view) must be dropped below the other or foot end so that the film will be parallel to the plane of the true conjugate diameter. This proportion, then, would be as follows:

Actual true conjugate diameter in cm. (A)	Difference in height in cm. between symphysis pubis and sacral promontory (*B*)
::	
Over-all length of 14×17 in. cassette in cm. (*A'*)	Distance in cm. necessary to drop sacral promontory end of cassette (*B'*) below symphysis pubis end

As previously stated, the cassette is

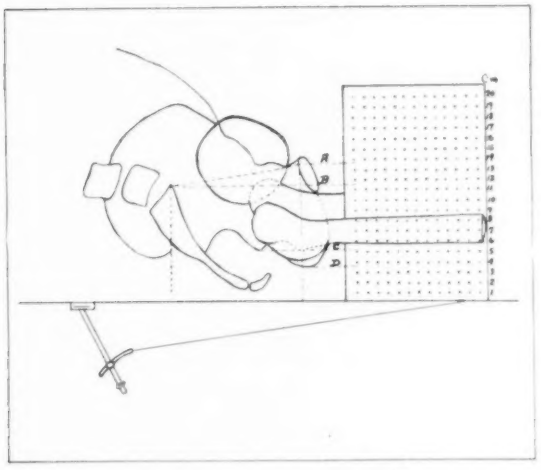

Fig. 3*b*. Sketch of lateral pelvis with erect perforated plate to demonstrate heights above table top of *A*, symphysis pubis; *B*, sacral promonotory; *C*, ischial spines; *D*, ischial tuberosities.

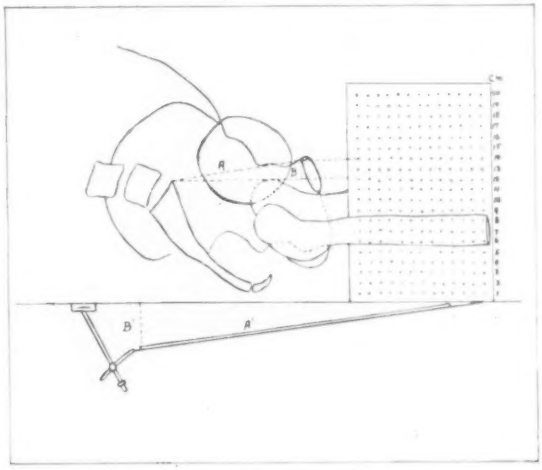

Fig. 4. Illustration of lateral pelvis and cassette beneath table showing that *A*, the true conjugate, has the same relation to *A'*, the cassette, that *B*, the difference in height above table between sacral promontory and symphysis pubis, bears to *B'*, the distance necessary to drop one end of the cassette to make the latter parallel to *A*.

readily placed at any desired angle beneath the table by means of the tilting hinged cassette holder arrangement. Then, to have the image of the pelvic inlet shown upon the film without any distortion from improper angling of the film, all that remains is to have the central ray passing through the pelvic inlet about 5 cm. posterior to the upper margin of the symphysis pubis and directed perpendicularly to the film. This can be done by means of a pointer, or one may use an all-angle level to obtain the angle of the cassette after the above calculations are made. The tube is then set at the same angle, centering to the center of the film.

Because it is somewhat time consuming to work out the above proportion in each case, the following Table 1 is given, showing the necessary distance in centimeters to drop the sacral end of the cassette below the end nearest the symphysis pubis for various true conjugate diameters and various inclinations of the pelvic inlet, assuming the over-all length of the cassette to be 45 cm.

A more simple method of determining the angle at which to place the film under the table is as follows:

Fig. 5. Arrangement of patient, tube and film for examination in the anteroposterior projection.

Determine the true conjugate diameter, and the heights of the symphysis pubis and sacral promontory above the table as previously described. Now place a perforated aluminum plate of the same length as the true conjugate in the grooves of the apposing stationary and movable uprights of the wooden frame at heights corresponding to those of the sacral promontory and symphysis pubis, adjusting the movable upright according to the length of the true conjugate. If the all-angle level be placed

Table I

Necessary distance in centimeters to drop one end of cassette which is 45 cm. in length for true anteroposterior view of pelvic inlet

Actual True Conjugate Diameter in Centimeters	Difference in Height in Centimeters between Symphysis Pubis and Sacral Promontory Distance in Centimeters Necessary to Drop Sacral End of Cassette Below Symphysis End								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
7.5	6	9	12	15	18	21	24	27	30
8.0	5.6	8.4	11.2	14	17	19.7	22.5	25.3	28
8.5	5.3	8.0	10.6	13.2	16	18.5	21.1	23.8	26.4
9.0	5.0	7.5	10.0	12.5	15	17.5	20	22.5	25
9.5	4.7	7.1	9.4	11.8	14.2	16.5	18.9	21.3	23.6
10	4.5	6.7	9.0	11.2	13.5	15.7	18	20.2	22.5
10.5	4.3	6.4	8.5	10.7	12.8	15	17.1	19.3	21.4
11	4.1	6.1	8.2	10.2	12.2	14.3	16.3	18.4	20.4
11.5	3.9	5.8	7.8	9.8	11.7	13.7	15.6	17.6	19.5
12	3.7	5.6	7.5	9.4	11.2	13.1	15	16.8	18.7
12.5	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18
13	3.4	5.2	6.9	8.6	10.4	12.1	13.8	15.5	17.3
13.5	3.3	5.0	6.6	8.3	10	11.6	13.3	15	16.6
14	3.2	4.8	6.4	8	9.6	11.2	12.8	14.4	16

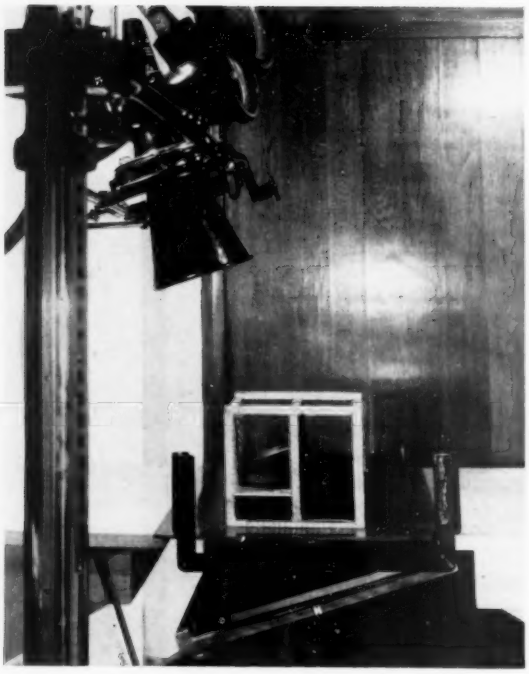

Fig. 6. Arrangement of tube, plate marker frame and film for making "key plate." This is made immediately after examining the patient in the anteroposterior projection.

on this aluminum plate, the angle can be determined at once, and the cassette beneath the table, as well as the tube above the table, can readily be placed at the same angle. This eliminates the need of more complicated calculations and is easier from the technician's standpoint.

In determining the exposure for the anteroposterior view, the greatest anteroposterior diameter of the abdomen with the patient recumbent is measured. As an example, for a woman measuring 25 cm. the following factors are used: 74 kv. (peak), 50 ma., 3 seconds, 36 inch distance, wafer stationary grid and par speed screens.

Upon completion of this second exposure, the patient is removed from the table, care being taken that the table and tube positions are not disturbed. The perforated aluminum plates are now placed in position in the wooden frame, one being placed in the center at heights corresponding to the previously measured heights of the symphysis pubis and the sacral promontory above the table top and indicated as "plate number 1" by placing a lead numeral "1" on the plate. Plate number 2 is placed in one side of the frame at a height corresponding to that of the ischial spines, as determined by inspection of the film made in the lateral projection while plate number 3 is placed in the other side of the frame, the height being that of the ischial tuberosities, lead numerals being used to designate the respective plates. Each plate is separated transversely about 0.25 cm. from the adjacent plates in order that overlapping may not occur. The frame is then placed on the table in the place previously occupied by the patient in such position that a line drawn from the center of the cone on the roentgen tube to the midline of the cassette holder will pass approximately through the center of plate number 1. Care must be exercised that the end of the frame corresponding to the position of the symphysis pubis is placed next to the foot end of the table. If the ends are reversed, naturally plate number 1 will not be in the same plane as the true conjugate diameter. This would not make any difference in the case of the markers for the ischial spines and tuberosities, inasmuch as they are placed parallel to the table top, our only concern here being to measure transverse diameters. With plate number 1 we are measuring both the true conjugate diameter, which is at an angle with reference to the table top, and the greatest transverse diameter of the pelvic inlet, the plane of which is parallel to the table top.

The image of the aluminum plates may be put on the 14 by 17 inch anteroposterior film of the pelvis, but this tends to partially obscure the bony landmarks, particularly if superimposed upon the shadow of the fetal head. Therefore, in practice the 14 by 17 inch film is removed and a 10 by 12 inch film is placed in the same position, this when exposed and developed serving as a "key plate."

The markers being in position, a flash exposure is made, using 41 kv. (peak), 50 ma., 1/10 second, 36 inch target-film distance.

Measurements of the anteroposterior

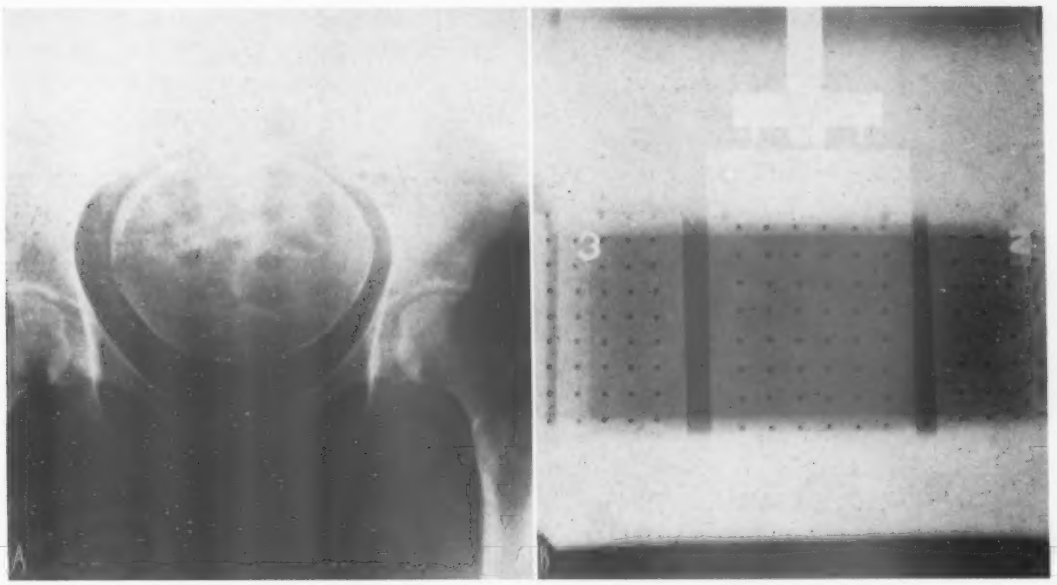

Fig. 7.1. Anteroposterior view of pelvis made with beam directed perpendicular to plane of pelvic inlet and with film beneath table parallel to this plane. Black dots indicate points from which to measure for bi-ischial and intertuberous diameters, respectively.

Fig. 7*B*. "Key plate," made immediately after the anteroposterior film of the pelvis has been exposed. Plate number 1 is in the same plane as the true conjugate. Plates number 2 and 3 are in the planes of the ischial spines and ischial tuberosities, respectively.

view may be made on either the wet or dry film. To measure the true conjugate, one simply counts the number of perforations on the shadow of plate number 1 corresponding to the measured distance between the posterior border of the symphysis and the sacral promontory. If enough perforations cannot be visualized, this diameter may be determined by simple proportion, as below. This measurement should serve as a check on the one previously obtained on the film made in the lateral projection, but in practice it has been found extremely difficult to locate the sacral promontory accurately in the anteroposterior view.

To find the greatest transverse diameter of the pelvic inlet, measure this distance on the film with a centimeter ruler. Then measure five perforations of plate number 1 in the transverse direction. Suppose the measurement of five perforations equals 6 cm. on the centimeter ruler and that on the film the measured distance of the greatest transverse diameter of the pelvic inlet was 15 cm. Then by proportion, $6:5::15:x$, where x equals the actual greatest transverse diameter, which in this case would be 12.5 cm.

The bi-ischial and intertuberous diameters are found in the same way, plate number 2 being measured transversely for the bi-ischial diameter and plate number 3, transversely for the distance between the ischial tuberosities. Of course, the transverse diameters must all be determined by proportion, as above, since one could not use three markers each of sufficient width to measure the various diameters directly.

The posterior sagittal diameter of the pelvis may also be found from the lateral view. This diameter is taken to represent the distance in the mid-sagittal plane from a point midway between the ischial tuberosities to the sacrococcygeal junction. Some difficulty may be encountered in determining the actual position of the tuberosities in the lateral view of the pelvis. Snow and Lewis[3] draw a line along the anterior or lower border of each obturator foramen. The points at which these lines pass through the lower edges of the ischial rami represent the position of the tuberosities. This

can easily be corroborated by inspecting a skeleton pelvis. A mark is placed on the film midway between the points denoting the tuberosities. The distance on the film from this point to the sacrococcygeal junction is measured. Magnification can be corrected in the same way that the actual true

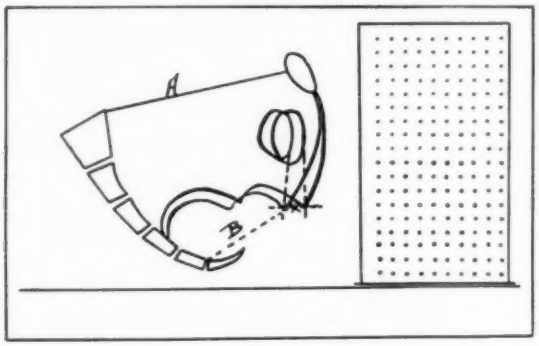

Fig. 8. Drawing of lateral pelvis and erect centimeter-perforated plate. *A*, true conjugate; *B*, distance in sagittal plane from level of ischial tuberosities to sacrococcygeal junction = posterior sagittal diameter of the pelvic outlet.

conjugate is determined in this view, since both diameters are in the mid-sagittal plane of the pelvis.

In addition to the above examinations it is helpful to obtain a view of the subpubic arch. This can readily be secured by the method which has been described by Caldwell, Moloy and Swenson.[2] Using a 10 by 12 inch film, and centering at the level of the anterior superior iliac spines, the tube is angled 45° toward the patient's head and then moved toward the foot end of the table about 13 inches. An exposure is now made, the voltage being variable. In a patient measuring 25 cm. the factors are: 75 kv. (peak), 25 ma., 3 seconds, 30 inch distance, Potter-Bucky diaphragm, par speed screens.

Cephalometry. The method which Ball[1] uses to determine the diameters of the fetal skull and maternal pelvis and the volume of the fetal cranium, as well as the volume capacity of planes of the pelvis at the levels of the inlet and bi-ischial spines, appears to be not only accurate but very practical. By use of the Moloy type of precision stereoscope[2] accurate measurements of the fetal skull and maternal pelvis may be obtained, and in addition one can readily visualize and study cephalopelvic relations during labor. The method of pelvic mensuration described in this paper was not originally intended to give any information concerning measurements of the fetal skull. However, as previously indicated by Thoms,[7] it has been found that where the fetal head is at the pelvic inlet, particularly if engagement has begun, measurements may be determined on the film made in the anteroposterior projection by the perforated plate method. By using plate number 1 on the key plate, actual measurements of the skull may be made in two diameters. These measurements are found to agree very closely with those obtained by use of the precision stereoscope, when both methods are used to examine the same patient.

By setting up a phantom pelvis and fetal skull, using small pieces of lead to indicate various boundaries, the accuracy of fetal skull measurements at any particular level can be demonstrated. As shown in Figure 10, one of the perforated aluminum plates was placed horizontally in the midline of the wooden marking frame at a height of 12 cm. above the table top and pieces of lead were placed on this plate to indicate

Fig. 9. The subpubic arch.

the level of the greatest transverse diameter of the pelvic inlet. In the same frame a second perforated aluminum plate was placed horizontally at a height of 18 cm. above the table top. On this latter plate small pieces of lead were placed to represent the anterior and posterior boundaries of an imaginary fetal skull and also the

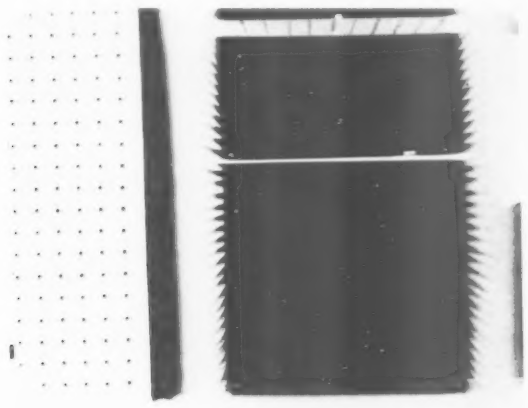

Fig. 10. Lateral view of marking frame in use as a phantom, with small pieces of lead placed to indicate boundaries of a fetal skull at a height of 18 cm. above the table top or 6 cm. above the plane of the greatest transverse diameter of the pelvic inlet, also indicated by small lead squares. By measuring the distance between the outer limits of the lead squares in the sagittal plane and then measuring an equal distance on the erect centimeter-perforated plate, a figure of 9 cm. is obtained.

lateral boundaries, assumed to be at this level above the table top. With the erect centimeter-perforated plate in the sagittal plane of this setup, a lateral film was made. Following the making of this film the marker indicating the greatest transverse diameter of the pelvic inlet was removed and an anteroposterior view of the markers representing the fetal skull set at a height of 18 cm. above the table top was made. Inasmuch as these markers were resting upon the perforated aluminum plate, an additional key plate was not necessary, and it is found that by simply counting the number of perforations and fractions thereof between the outer edges of the lead markers, the measurements obtained on the film correspond exactly with the figures as determined by direct measurement.

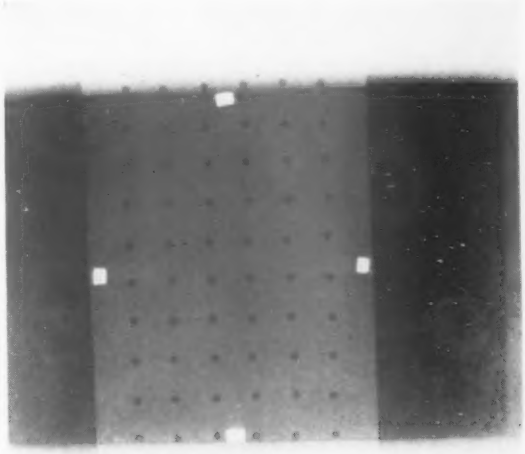

Fig. 11. Anteroposterior view of wooden marking frame used as a phantom with lead markers indicating fetal skull boundaries. These markers are resting on the aluminum perforated plate which has been arbitrarily placed at a height of 18 cm. above the table top. The distance separating the markers is readily determined by reference to the perforated plate. Note that the distance between the outer limits of the lead squares in the sagittal plane, after correcting for magnification by means of the key plate, is 9 cm. as on the lateral view in Figure 10.

The position of this plate with the four lead markers was now changed to a height of 12 cm. above the table top, this height being at the same level as that of the greatest transverse diameter of the pelvic inlet in the lateral view. An anteroposterior view was made with the markers in this position and as shown in Figure 12.

The measurements are the same as those found when the markers were at a height of 18 cm. It is therefore seen that if in actual practice the level of the fetal skull to be measured is first determined on the lateral view, correct sagittal and transverse measurements can be made on the anteroposterior view of the pelvis by use of a key plate as above described.

A valid objection to this method of measuring the maternal pelvis and fetal skull is the presence of a special table in the roentgen department. Measurements have therefore been made using the Potter-Bucky table, with the skeleton pelvis as the sub-

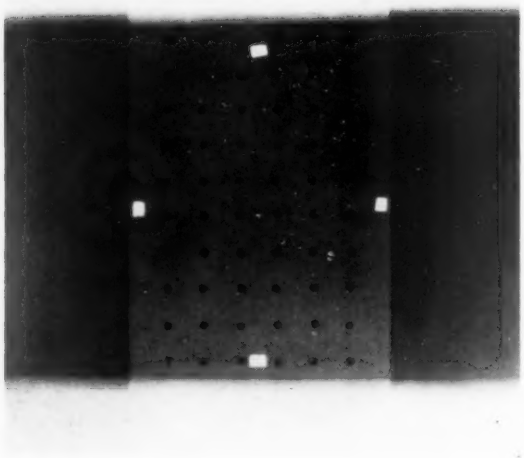

Fig. 12. This is the same view as in Figure 11 but with the lead markers placed at a height of 12 cm. above the table top. Change in magnification due to change in distance of the markers above the film has affected equally the perforations in the aluminum plate and the distances separating the various markers; consequently, the actual measurements remain the same as in Figure 11.

ject. The measurements correspond to those obtained on the same pelvis by direct measurement, as well as by the special method above described, a difference of not over 1 mm. being found for the transverse diameters. Of course the true conjugate diameter cannot be satisfactorily determined in this way because, except in the rare case, the plane of the pelvic inlet will not be parallel to the film. However, this measurement as previously mentioned is not as accurate in the anteroposterior as in the lateral view, and the main value in having the film parallel to the plane of the pelvic inlet lies in obtaining a true view of the inlet. In making the lateral view it is necessary as in the first method to use a wafer grid, or a mobile Potter-Bucky diaphragm. Also, the patient must be elevated above the table top a distance of about 2 inches, supported on some relatively nonopaque material such as cellulose sponge. Otherwise the shadow of the sacrococcygeal spine will be lost in the shadow of the table's edge. The film with one edge resting on the table is supported beside the patient by the use of sand bags. A light frame with a channel at the side to hold the film for the lateral view could be readily devised and this could be placed on top of the Potter-Bucky table when this type of examination is required.

SUMMARY

A method of determining the various pelvic diameters by the use of perforated metal plates is presented. Lateral and anteroposterior views are made, with the patient lying in the recumbent position for both films. By this means the true image of the pelvic inlet without any distortion other than that of magnification is obtained. Both inlet and outlet diameters may be found, the results being sufficiently accurate for all clinical requirements. Certain diameters of the fetal skull may also be obtained in skull presentations by the same method.

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Vol. 47, No. 3

SIGMOID LOOP IN AN INGUINAL HERNIA*

REPORT OF A CASE

By C. G. LYONS, M.D., A. J. BROGAN, M.D., AND J. G. SAWYER, M.D.
Veterans' Administration
HINES, ILLINOIS

REDUNDANT colon or dolichocolon is an anomaly of length of the large bowel. It is an elongation of one or more parts of the colon so that the portion of the bowel affected is reduplicated and occupies an abnormal position in the abdomen. The portion of the large intestine most commonly affected is the sigmoid.

This anomaly is a relatively frequent one, as evidenced by reviewing several of the more extensive studies made in this field both roentgenographically and by autopsy. Kantor[1] in 1924 reported an incidence of 62 cases in a series of 668 patients with various gastrointestinal complaints who were studied by roentgen examination. This same author[2] reported another series of 1,850 barium enema studies in 1934 and found 343 cases of redundant colon in this group. Bryant[3] in 1924 reported a series of 160 postmortem studies of the large bowel and found an incidence of 15 per cent of this anomaly. In 1926 White[4] found 43 cases in a series of 1,000 consecutive patients studied from a gastrointestinal standpoint.

It is interesting to note that in none of the above extensive series of cases reported was mention made of the presence of a redundant loop of sigmoid in a hernia or even the possibility of its occurring. Over a period of thirteen years at this Facility, which has a capacity of over 1,700 beds, this type of hernial contents has not been previously demonstrated roentgenographically. Possibly this is due to the fact that the diagnosis of a hernia is usually so obvious that the patient is subjected to surgical treatment without undergoing previous barium enema studies which in most cases of hernia would seem to be unnecessary.

It is because of the rarity of this roentgen demonstration in our experience and the evident rarity of it in the literature that the following case is reported.

CASE REPORT

The patient, W. W. H., a white male, World War I veteran, aged forty-eight, was admitted to this Facility February 7, 1940, complaining

FIG. 1. Barium enema outlining the colon. Arrow points to a redundant loop of sigmoid incorporated within the contents of the scrotal hernia.

of fever, sweats and a loss in weight of 20 pounds since the onset of his present illness on January 3, 1940. At that time, and for three weeks thereafter, his chief symptoms were fever and weakness; he had no complaints referable to the chest. On January 17, 1940, he was taken to a private hospital for observation. After a week there, his fever became suddenly higher

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and he complained of sharp stabbing pains in the upper abdomen which radiated around to the small of the back. There was no cough or expectoration. This acute episode of aggravated symptoms lasted three days, following which the patient felt better. He remained in the hospital until his transfer to this Facility. Five days prior to admission here, a severe aching pain developed in the right lower extremity, with no redness, localized swelling or tenderness.

His past history included complaints of "belching and sour stomach" for the past ten years for which he had never received treatment. He also stated he had had a hernia in the left groin for several years (no definite length of time being remembered) which had never caused him any symptoms. A truss had never been worn. There was a history of an attack of thrombophlebitis, of unknown etiology, in the right lower extremity, which occurred eight years previously. A similar attack in December, 1938, confined the patient to bed for five weeks.

Past history relative to accidents, operations or venereal exposure revealed nothing positive.

General physical examination of the patient disclosed the following significant findings: (1) evidence of uniform enlargement of the right lower extremity, due to an old thrombophlebitis of the right femoral vein; (2) a large inguinal hernia on the left side, extending into the scrotal sac, which was easily reducible.

Roentgenographic examination of the chest, on February 9, 1940, revealed no definite information except for an abnormally elevated diaphragm on the left side, suggestive of pressure upwards from below. Barium enema examination of the large intestine, on March 8, 1940, to rule out a possible tumor causing the above mentioned displacement of the diaphragm, disclosed the presence of a long loop of sigmoid colon incorporated within the contents of a hernial sac on the left (Fig. 1).

The patient had had no complaints referable to the bowel, such as constipation, diarrhea, etc.

Laboratory studies, including urinalysis, blood serology, blood counts and blood cultures, revealed nothing significant.

The patient felt generally well during his term of hospitalization here and his temperature curve remained within normal limits.

The final diagnoses made were: Recurrent, old thrombophlebitis of the right femoral vein and left inguinal hernia.

A surgical repair of the hernia was performed by a modified Bassini technique on April 1, 1940. The postoperative course was uneventful and the patient was discharged April 18, 1940.

The authors are indebted to Ralph P. Creer for his aid in preparing the print of the illustration accompanying this article.

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Vol. 47, No. 3

THE EFFECT OF ROENTGEN RAYS UPON THE GROWING LONG BONES OF ALBINO RATS*

I. QUANTITATIVE STUDIES OF THE GROWTH LIMITATION FOLLOWING IRRADIATION

By CHARLES L. HINKEL, M.D., Med.Sc.D.
HARRISBURG, PENNSYLVANIA

HISTORICAL

THE effect of irradiation upon the growth of long and flat bones has been of interest ever since the discovery of the lethal effects of gamma and roentgen rays. The first recorded observations along these lines are those of Perthes[43] in 1903, who produced retardation of development in the wings of day old chickens by exposure to roentgen rays.

In 1905 Tribondeau and Récamier[60] showed a similar effect upon the cranial bones of the cat, and noted also generalized stunting of the entire skeleton. It seems probable that the latter phenomenon was the result of irradiation of the pituitary or other intracranial structure rather than a generalized effect of the rays.

A year later Försterling[24] confirmed this local effect of stunting due to irradiation, and described soft tissue atrophy in rabbits, dogs and goats. Latarjet[37] in 1912 showed that the bones of irradiated rabbits were retarded in length and thickness. Other early investigators, notably Segale,[50] Iselin,[34] Walter[61] and Baunach[3] described qualitative stunting in a number of common laboratory animals.

In none of the above work was the quality or quantity of radiation expressed in terms of modern units. For this reason the early reports have but limited quantitative analytical value.

More recent and accurately standardized experiments by Brooks and Hillstrom[9] showed that in rabbits from twenty-one to seventy-seven days of age, bony shortening could be produced by 40, 60, 80 and 100 per cent S.E.D. (human skin erythema dose). The shortening was roughly proportional to the amount of roentgen radiation administered. It was stated, however, that one erythema dose produced the same effect in all age groups.

Regan and Wilkins,[46] in 1936, showed complete cessation of growth in the forelegs of young rabbits treated with 2,600 r in one sitting.

Bisgard and Hunt[6] in the same year, using rabbits three to five weeks old, found that 1,540 r to the forelegs produced no shortening if the epiphyses were protected with lead, but in four week old rabbits, 400 r produced gross retardation when the epiphyses were included in the field. These workers stressed the great lessening of effect produced by fractionation of the dose.

Dahl[15] (1936) carried out several exhaustive studies on irradiation effects in rats. He used large fields and massive doses on animals twelve to eighteen days of age. His animals showed growth cessation, spontaneous fractures, and resorption of bone fragments. In his monograph Dahl[14] states that the effect upon the "cartilage of conjugation" was always proportional to the skin reaction, but that the "zone of growth was not more radiosensitive in the youngest animals than in the oldest animals."

In 1930 Flaskamp[23] stated that 25 per cent of the skin erythema dose produced stunting in human infants, while more than 50 per cent S.E.D. could be given to older children without retardation of growth.

Baunach[3] (1935) showed that four week old rabbit bones were stunted by 220 r, but in eight week old rabbits 275–330 r was

* From the Department of Radiology of the Presbyterian Hospital and of the College of Physicians and Surgeons, Columbia University, New York. Condensed from a thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Medical Science in Radiology, June, 1940.

Fig. 1. *Roentgen Anatomy.* Normal osseous development of albino rat as seen in serial roentgenograms. Puberty corresponds to about six weeks (males) and ten weeks (females). After four months rats are mature. The climacteric corresponds to fifteen to eighteen months.

required to produce demonstrable effects.

These last two are the only concrete statements to support the vague but widespread supposition that the age of osseous and cartilaginous tissues is a factor in their radiosensitivity. The importance of this age factor will be discussed below.

Many early investigators refer to decalcification of bones following irradiation.[3,11,37] On the contrary, a form of condensing osteitis has been observed following radium implantation[11] and heavy surface irradiation.[22]

Numerous contributions have been made concerning the inhibiting effect of roentgen rays upon healing of fractures and surgically produced bone defects.[9,16,25,36,47] These will not be discussed here inasmuch as the mechanism differs from that in endochondral bone growth and bears only an indirect relation to the problem at hand.

PURPOSE OF EXPERIMENTS

Experiments were devised to study quantitatively the radiosensitivity of rat bone and cartilage throughout the period of active growth and to show the influence of age upon the effect produced. Several secondary experiments were designed to test some of the early theories advanced in connection with bone growth and roentgen-ray effects. One objective of this work was to determine whether a quantitative relationship between dose, age and growth inhibition due to roentgen rays existed or could be established.

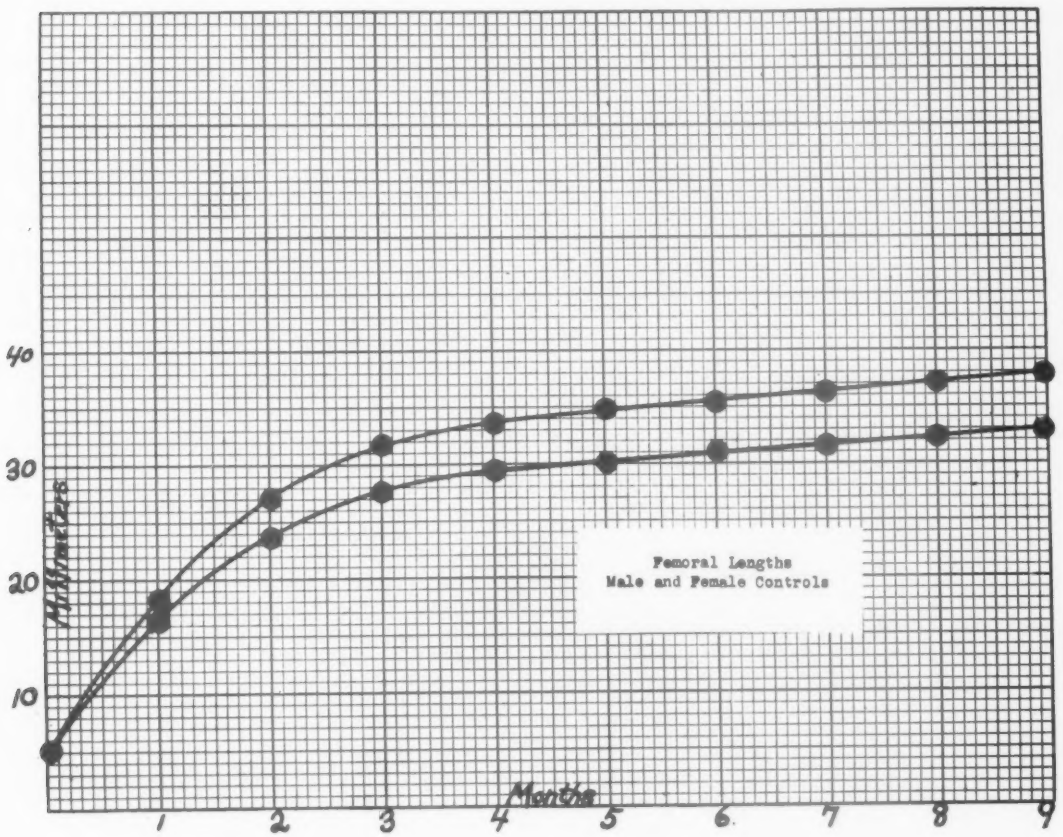


FIG. 2. *Normal Growth Curves.* Average lengths of male (upper) and female (lower) femora of control animals and unirradiated femora of exposed animals from birth to nine months of age. Males grow more rapidly and attain larger size than do the females.

GENERAL TECHNIQUE (ABBREVIATED)

Sherman strain albino rats were used in all experiments. They were all cared for in the same manner and fed on standard pellet diet. Anesthesia: Nembutal (Abbott) in aqueous solution was administered by the intraperitoneal route. The approximate dosage was 1 mg. per 40 grams. Immobilization: Animals were tied securely in supine position on an animal board. This position was utilized both for making roentgenograms and the administration of radiation. Administration of radiation: The entire amount of roentgen rays was administered in one sitting. The factors used were 200 kv., 25 ma., 50 cm. distance, filtration 0.5 mm. copper and 1.25 mm. aluminum.

By means of a heavy lead shield, the irradiation was sharply limited to a small field, 5 mm. in diameter. This small field was located on the anteromesial aspect of the right hind leg in such a position as to include the distal femoral epiphysis. The left femur of each animal was not irradiated and was used as a control.

GROWTH MEASUREMENTS

Following administration of the roentgen-ray dose each animal was immediately roentgenographed, and additional follow-up films were made at convenient intervals thereafter throughout the life of the animal. Because of the type of growth curves noted, no animal was followed for longer than one year. Nembutal was always used (as above) before taking films, and special care was exercised to extend the legs and keep the knees in contact with the film. The accuracy of measurements made from roentgenograms by this method was checked by actual measurements of dissected bones. In all age groups not more than 1 mm. of error was detected.

NORMAL OSSEOUS GROWTH IN RATS

A roentgenogram of the femur of a rat at birth shows a well calcified shaft about 7

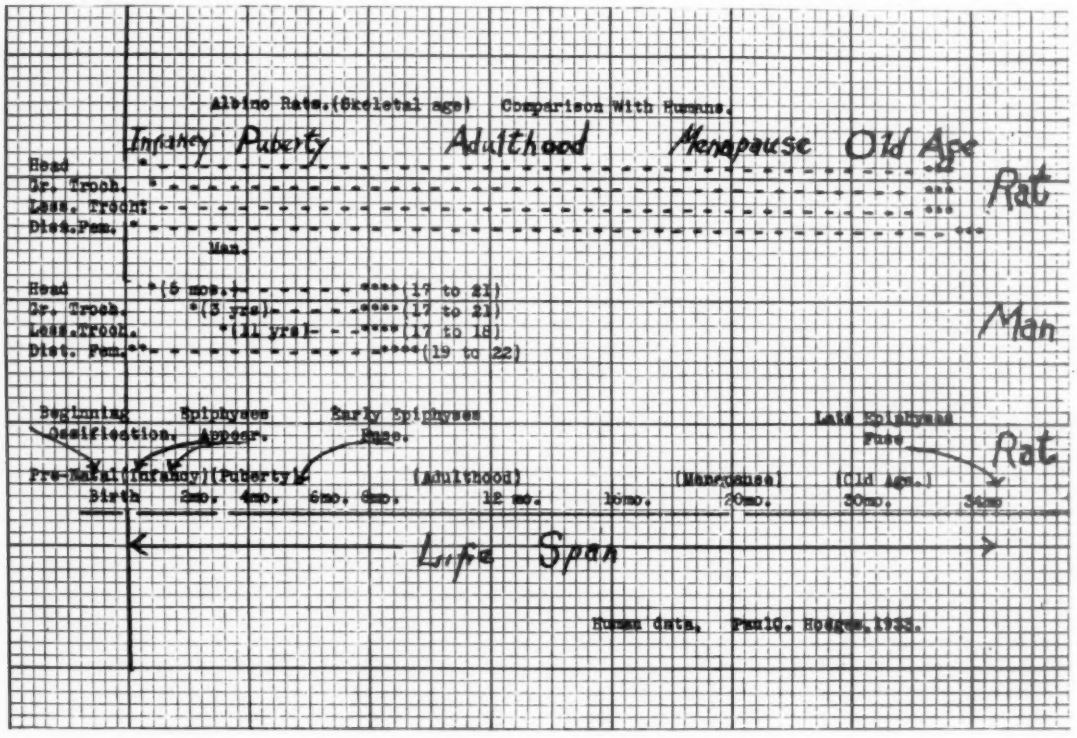


FIG. 3. *Comparison of Epiphyseal Closure Times, Rat and Man.* Comparison of the duration of femoral growth in the albino rat and man. Growth is completed in humans at adulthood, but rat femora grow until old age.

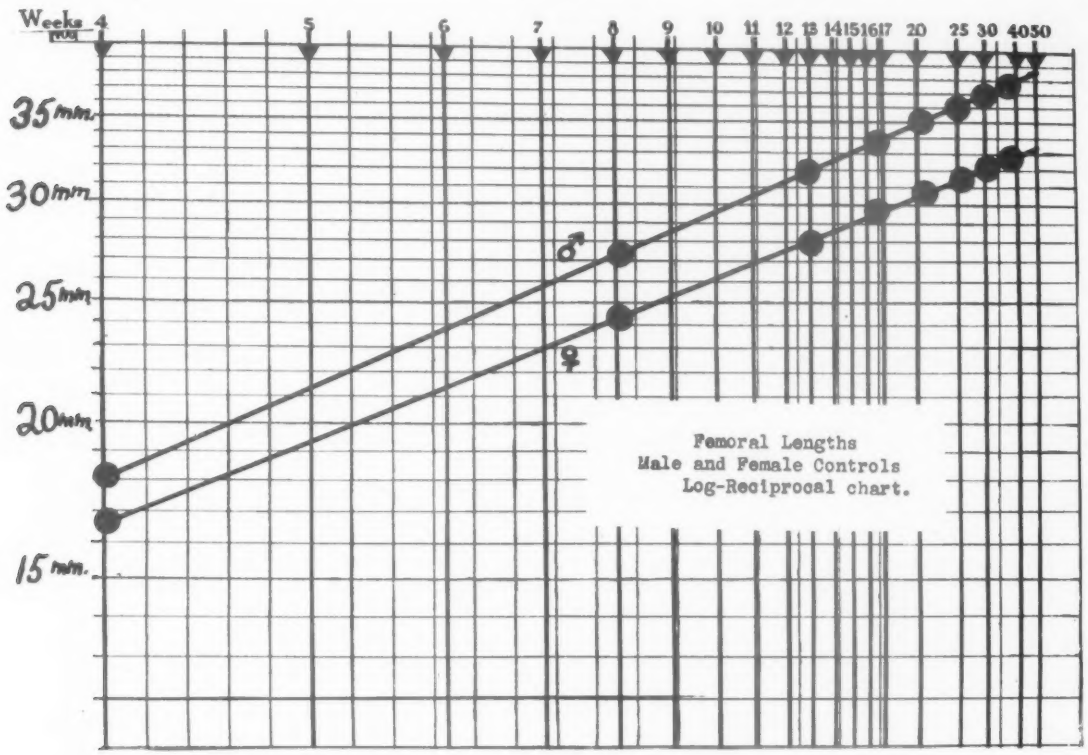


Fig. 4. *Normal Log-Reciprocal Slopes.* Same data as in Figure 2 plotted as logarithm of length against reciprocal of age in weeks. The male growth slope is somewhat steeper than that for females. Measurements plotted are at monthly intervals.

mm. long, having a tendency to flare out at the ends, which themselves are rather indistinct. In contrast with humans at birth, there are no secondary centers of ossification at the knee joint.[51] The rat at this time exhibits an immature skeletal development comparable to that of a human fetus of four and a half months.[49]

At eight days the three distal femoral centers of ossification which form the epiphysis appear and grow rapidly in size. They fuse into a bony plate by the end of third week, simultaneously with the appearance of the epiphysis for the femoral head. At one month the diaphysis and four secondary centers of ossification have assumed the shapes and proportions to be seen in the adult animal (Fig. 1).

After six weeks (adolescence), the femur undergoes but slight modification in shape and proportions. The bone continues to grow in length and thickness throughout life. This growth is most rapid in the first four months (into adulthood), but continues at a slower rate thereafter, so that careful measurements show growth even after the menopause and into old age (Fig. 2).

While the epiphyses of nearly all the other long bones have fused by four and a half months, those of the distal femur, femoral head, and both greater and lesser trochanters remain unfused as late as thirty-four months.[21] This peculiarity of growth is distinctly different from that in human long bones,[11,55,58] all of which cease growing at the beginning of adult life (Fig. 3). It does, however, agree closely with numerous growth curves in nature, and, as has been recently pointed out by Zucker,[63] the logarithm of the bone length bears a linear relationship to the reciprocal of time (age).* This relationship does not

* I am greatly indebted to Dr. Zucker and his staff for their technical help and intellectual guidance. The log-reciprocal relationship has been of great assistance in the analysis of growth curves.

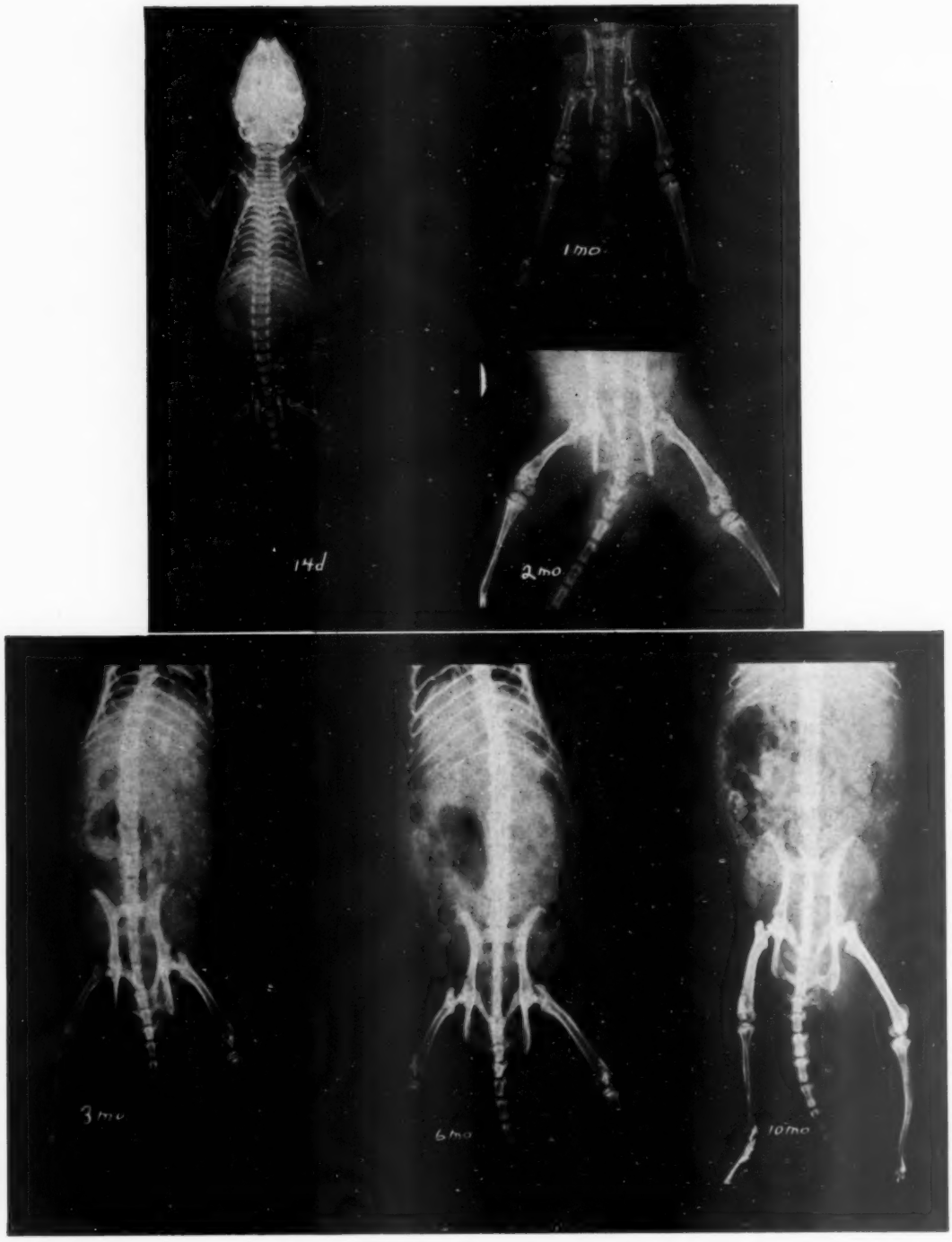


Fig. 5. *A Typical Result in a Single Animal.* Selected films of rat No. 86. This animal received 1,000 r at age eleven days. The concomitant shortening of the tibia indicates that due to the small size of the animal the irradiation could not be limited to the femoral epiphysis and included the upper end of the tibia as well.

apply in animals younger than one month or in malnourished animals. When plotted in this manner, the growth curves of all the femora of control animals as well as of the untreated legs of the irradiated animals in this study, form straight lines from one

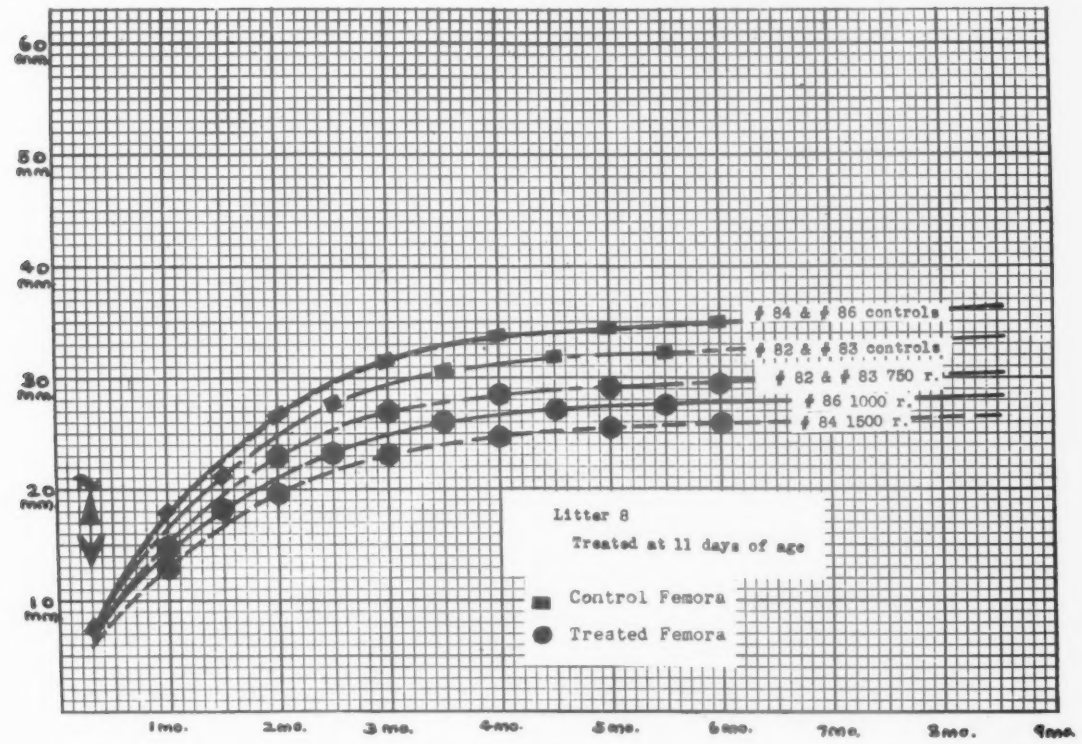


FIG. 6. *Litter 8.* Composite graph of femoral lengths of 4 members of litter 8. The distal end of the right femur of each was irradiated at eleven days of age (arrow). The non-irradiated femur of each animal serves as a control (black squares).

month onward throughout the experiment.

Figure 2 shows the average measurements in millimeters of the male and female femora obtained from roentgenograms of the normal control bones in this series. Figure 4 shows the same data plotted in the log-reciprocal manner. It is obvious that for ready comparison and accurate analysis, the latter has great usefulness.

GROSS CHANGES

Following effective irradiation of the distal right femur, there was interference with normal growth as evidenced by the serial roentgenograms. A single animal No. 86 will serve as a typical example. One thousand roentgens were delivered to the right knee at the age of eleven days. Some of the subsequent films of this animal are shown in Figure 5.

In most of the experiments, films were made of each animal at monthly intervals following irradiation. Measurements were made in millimeters directly from the roentgenograms and were plotted on ordinary graph paper (Figs. 6 and 7). The curves for the treated and untreated femora diverge rapidly at first. After a few months, however, they appear to run almost parallel throughout the remainder of the observation period.

Figure 6 is a graph representing the femoral lengths of both irradiated and control femora in the animals of litter No. 8. The amounts of radiation administered are indicated. Figure 7 is a similar chart made from the data of litter No. 9. The measurements of these two litters of animals illustrate the quantitative nature of the response to various amounts of roentgen radiation.

After the initial period of increasing difference in length, the two femora of each rat appear to maintain the same length relationship to each other. This is more strikingly brought out when the femoral

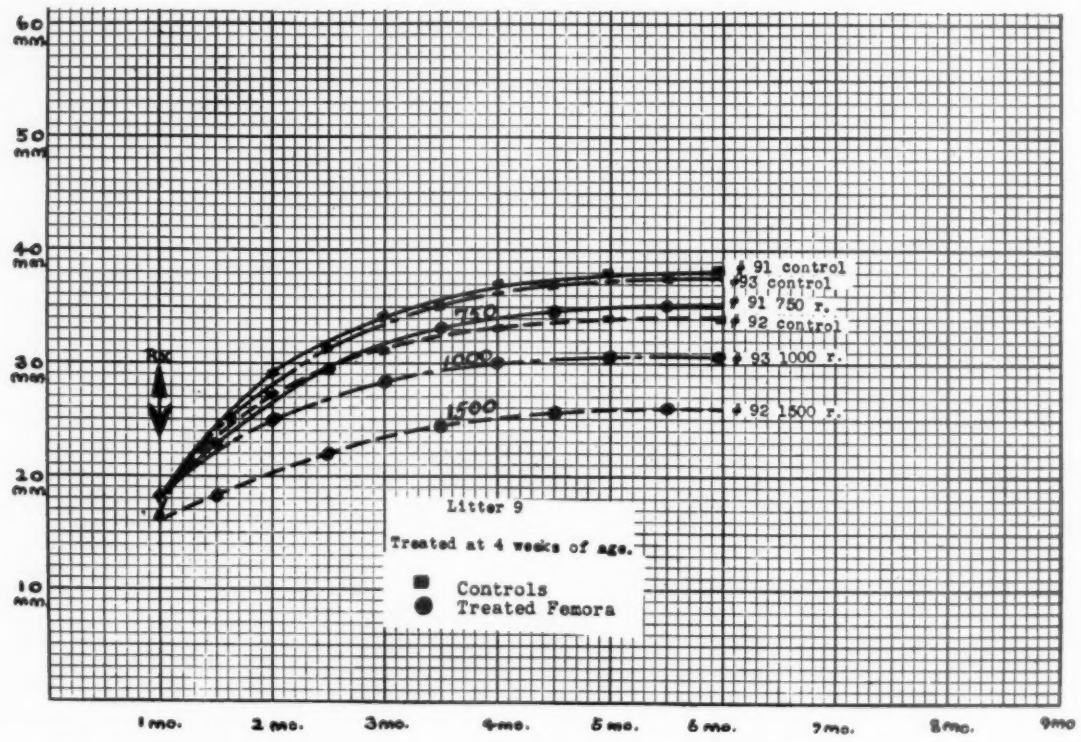


Fig. 7. *Litter 9.* Irradiated femora (●) and control femora (■) of litter 9. This shows the quantitative effects of 750, 1,000, and 1,500 r administered at one month (arrow).

lengths of litter No. 9 are plotted on log-reciprocal paper (Fig. 8). In brief, it appears that following the initial irradiation injury and inhibition of growth of the treated limb, there is a quite satisfactory recovery of growth function so that the stunted femur, although shorter, grows at the same slope of log-reciprocal curve as the untreated femur. This finding of parallelism of the stunted and unstunted femora was present in all animals irradiated during the active phase of growth (up to four months). It was not observed in those animals which received such large dosages in adulthood that growth was completely and permanently abolished. Throughout the following pages, unless otherwise stated, it may be assumed that the animals under discussion were treated in such a way as to permit subsequent growth.

Determination of Minimal Stunting Dose

The quantitative appraisal of irradiation effects in growing animals is difficult. Large doses cause marked bony retardation or cessation of growth, smaller doses cause less retardation, and still smaller doses fail to produce any grossly recognizable change.

It must be remembered that the amount of stunting of the treated femur as compared with the contralateral one depends upon the age. In an animal one or two weeks old, shortening of the treated bone is readily perceptible because the normal bone quickly outdistances the retarded one, thus accentuating the disproportion. In older animals the growth rate is so much slower that when stunting is produced after four months of age, it is necessary to continue the observation many weeks in order to allow sufficient time for the normal leg to outdistance its fellow. It is obvious that the amount of stunting per se can be considered a quantitative measurement of irradiation effect only when the animals used are the same age. A large dose of roentgen rays was delivered to an animal (Fig. 9) at the age of five months, but due to the flattened growth curve at this time only

slight stunting resulted.

It appears that the only way to analyze the sensitivity of the epiphyseal zones is to determine at many ages the dose required to produce mimimal recognizable stunting.

As there was practically no precedent, the doses administered were chosen arbitrarily. Each litter of animals was treated on the same day, keeping all factors constant except the dose administered. This latter was varied for each animal and, in most litters, it ranged from an amount inadequate to produce bony retardation to an amount producing excessive stunting and soft tissue damage.

Using this method, litters were treated at many ages, including one, three, six and eleven days, two, four and six weeks, and three, four, five and six and a half months. By observing the growth of bones on the follow-up films, it was possible to determine the minimal dose which produced gross stunting in each litter. These minimal stunting doses are graphically shown in Figure 10.

The curve shows a plateau in the first ten days of life, after which the minimal stunting dose rises steadily, maintaining a linear relationship to the age of the animal. The slope of the curve continues upward even though the normal femoral growth rate (Fig. 2) has decreased markedly. It appears from this that in the rat femur the sensitivity of bone to irradiation decreases with increasing age but is not proportional to the rate of growth.

AGE AND IRRADIATION EFFECT

The relationship of age of a cell to its radiosensitivity remains largely unexplained.

The law of Bergonié and Tribondeau, introduced in 1906, states that the sensitivity of cells varies directly with their reproductive power and inversely with their degree of differentiation.[4] This is still a useful

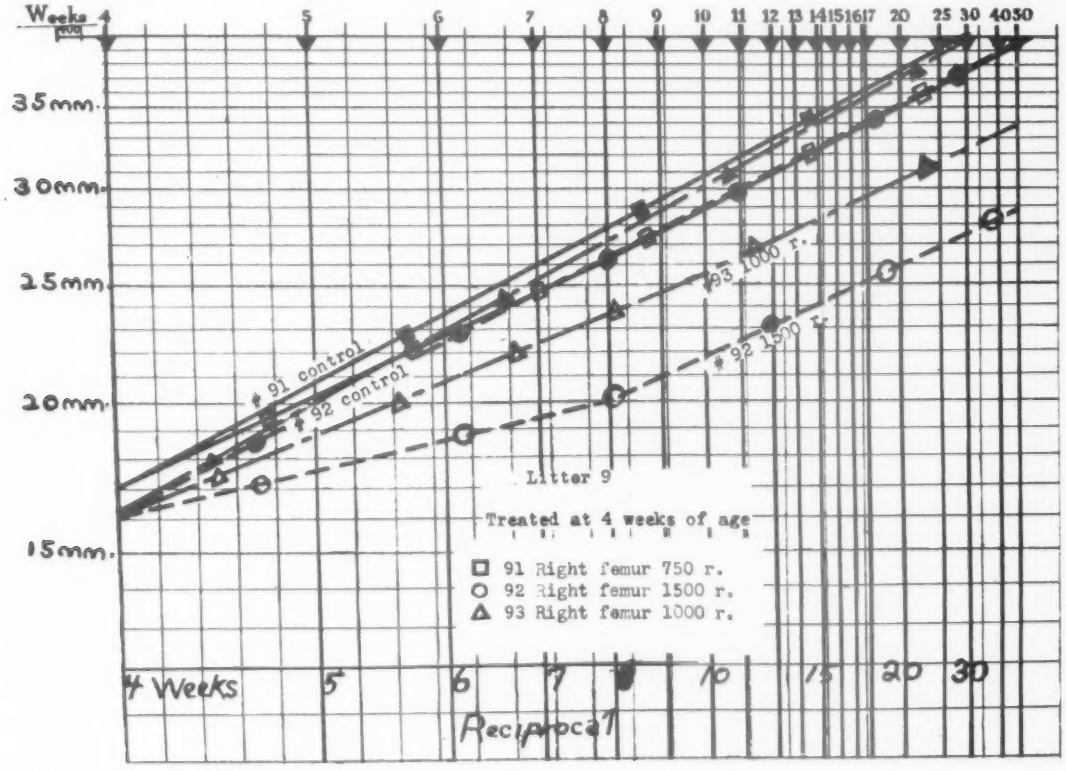


Fig. 8. *Litter 8. Log-Reciprocal.* Same data as in Figure 7 plotted on log-reciprocal paper illustrates clearly the return to normal growth rate following an interval of about four weeks of retarded growth. Animal No. 91—□; No. 92—○; No. 93—△.

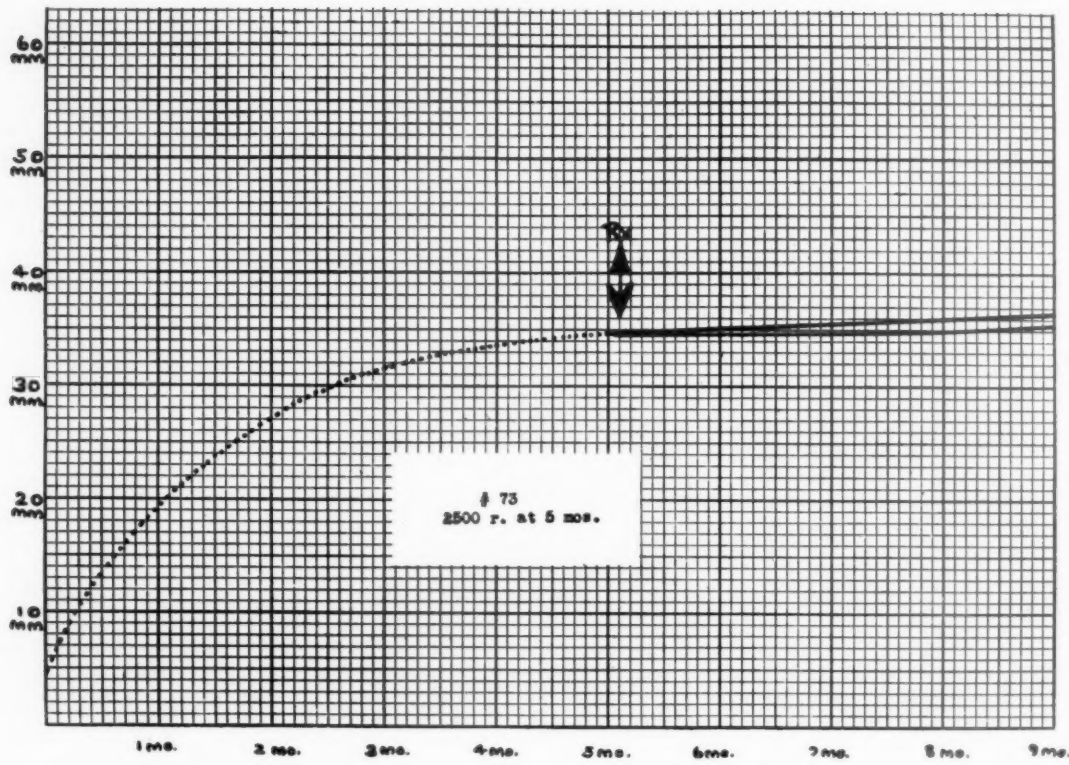
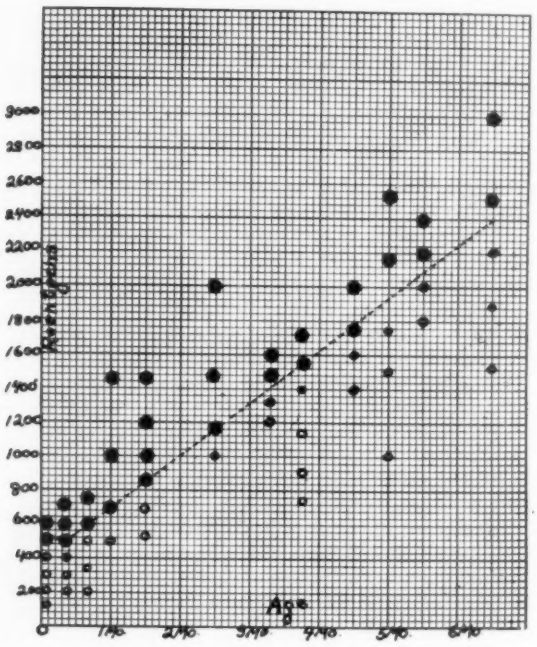


Fig. 9. *Stunting in Adult Animal.* Animal No. 73 received 2,500 r at five months of age. This produced only 1.5 mm. stunting in the subsequent four months. The control femur is growing slowly.



generalization but there are many undeniable exceptions.

Radioresistance generally increases with age but does not do so in a smooth or regular manner.[1,2] *Ascaris* eggs, *Asolotl* larvae and *Drosophila* larvae[31,32,40,62] all show marked fluctuations in their irradiation tolerances at different developmental stages. In the experiments here described it appears that there is little or no correlation between the growth rate or cellular activity and the irradiation tolerance, but the latter shows a direct linear correlation with the age.

Fig. 10. *Minimal Stunting Dose Chart.* Each black circle represents definite grossly recognizable stunting which was observed to follow the indicated irradiation dosage administered at many different ages. Each open circle represents a failure to produce stunting at the dose and age specified.

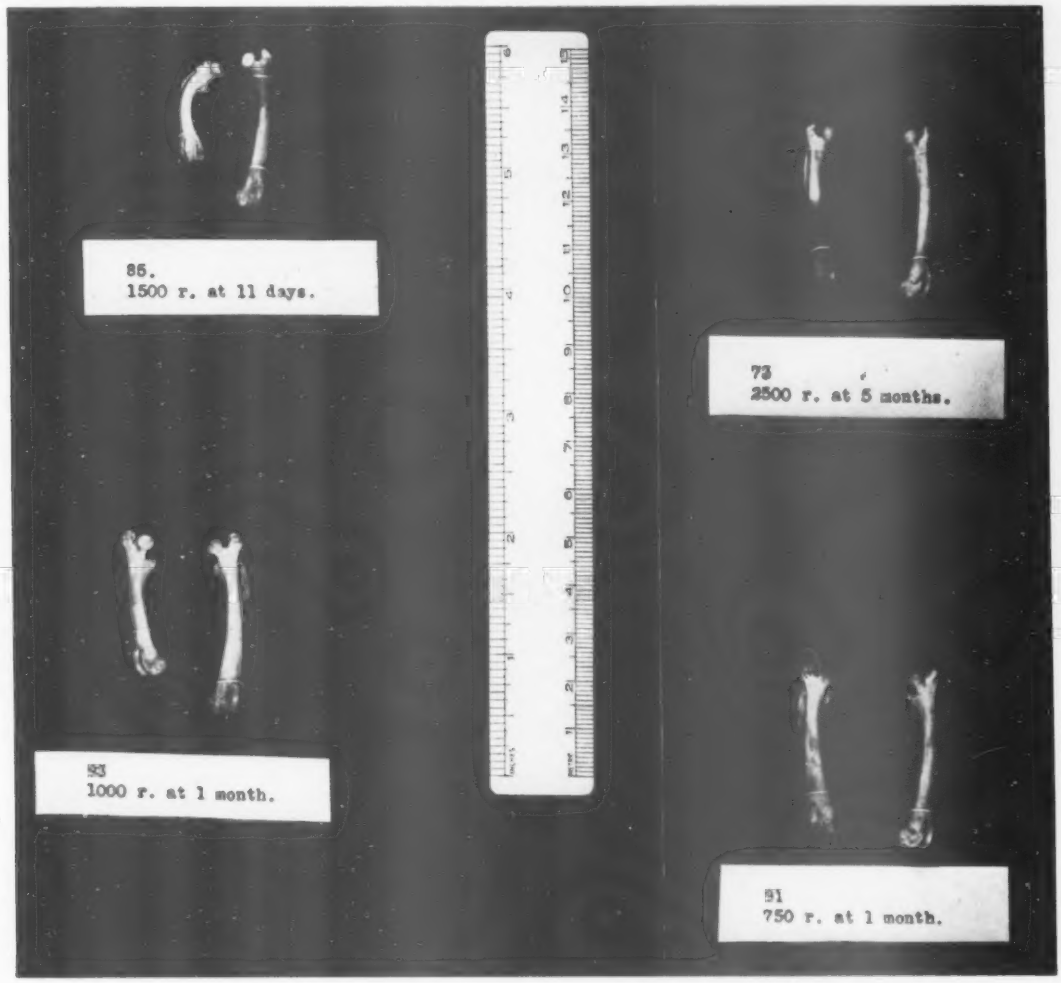


FIG. 11. *Gross Appearance of Stunted Femora.* Photograph of dissected femora from 4 animals. Rats No. 85 and No. 93 illustrate the curvature mentioned in the text. All the right femora shown here are stunted by the irradiation administered six to ten months before necropsy.

Recuperation or recovery from irradiation injury is another important factor in the observable effects. Recovery was much more active in the young, rapidly growing animals. Young animals were found to regain growth function in epiphyseal regions subjected to several times the minimal stunting dose. When older animals were given comparable overdoses, growth was permanently abolished.

RADIOSENSITIVITY IN VERY YOUNG BONES

At birth and in the first few days of life, the rat skeleton is very immature, composed largely of cartilage, and exhibits only beginning differentiation and arrangement into columns of cells. It would seem that if sensitivity to irradiation depended upon the degree of undifferentiation, then such very young animals should have radiosensitive femoral cartilages. An attempt was made to produce stunting by the use of very small doses during this period.

Many such young animals were given doses varying from 100 to 700 r, and it was found that at no age could stunting be produced by less than 500 r. This accounts for the flat portion of the curve in Figure 10,

which corresponds to the first ten days of life.

It is possible that the flattening of the minimal stunting dose curve thus produced may mean that the undifferentiated cartilage, which is deficient in typical growth columns, is less sensitive than the older, more highly organized cartilage. It seems more likely, however, that the plateau in the curve simply represents the "minimal effective dose" which will produce stunting at any age. This dose is larger than the smallest dose reported to cause stunting in rabbits[9] and rats.[14] In all previous investigations large fields were used. This factor may well explain the apparent discrepancy.

As has been repeatedly shown by others, no evidence of stimulation of growth by these small doses was ever noted.

ADDITIONAL OBSERVATIONS ON IRRADIATED ANIMALS

The femora of animals irradiated while young showed retardation in the growth in the transverse as well as longitudinal diameters. When the animal was so small that the 5 mm. aperture included the proximal tibial epiphysis, there was concomitant stunting of this bone (Fig. 5).

Certain femora receiving large doses at an early age showed a lateral curvature of the shaft distal to the intertrochanteric line. These bones also had an apparent increase in the prominence of the lateral femoral flange (so-called third trochanter) on the stunted side. These findings did not appear until several weeks after the stunting and may well represent changes secondary to the modified muscle stresses and mechanical imbalance caused by the short leg per se (Fig. 11). Animal No. 85 shows the most marked deformity encountered in these experiments.

The time of appearance, rapidity of growth, and ultimate size of the epiphyseal centers of ossification appeared grossly uninfluenced by exposure to the roentgen rays in the modrrate dosage range. When irradiation was carried out before the epiphyseal cartilage became calcified or if massive doses were given, the center appeared slightly smaller.

The sesamoid cartilages in the knees, which normally become calcified in rats at about thirty days of age,[57] also appeared uninfluenced by the roentgen rays.

Use of the 5 mm. aperture considerably decreases the backscatter and raises the amount of radiation tolerated by the skin.[39] Although there is some individual variation depending upon the age of the animal used, doses of about 1,200 r resulted in temporary and partial epilation; 2,000 r usually produced reddening of the skin, and doses of 3,000 r produced inflammatory changes which in some instances progressed to exudation followed by crusting. Even after doses of this magnitude, however, the skin always healed and hair grew again. In young but not in older animals, it was possible to stunt the femora without recognizable skin effect. It thus appears that the bone sensitivity is unrelated to that of the skin.

MINERALIZATION OF IRRADIATED BONE

Latarjet, Dahl, Baunach and others have previously alluded to the decalcification which was thought to follow irradiation of bones. The doses used were massive and the fields included most or all of the bone being treated. The following experiment was devised to determine whether such changes could be demonstrated several months after irradiation restricted to an area including only the distal growth center.

Method. Several animals were irradiated sufficiently to produce varying degrees of bony stunting. After several months had elapsed, these animals were killed and the femora dissected free. In addition, rat No. 74, which received 1,500 r without recognizable gross stunting, and animal X, which had never been irradiated, were included as controls. The animals ranged from four to nine months of age at necropsy, and the doses and ages are indicated in Table 1.

The femora were cleared and extracted in hot alcohol and ether in Soxhlet's apparatus for twenty-four hours. The dry, fat free

bone weights were obtained, measurements were recorded, and each was ashed to constant weight in a muffle furnace. The weight after this procedure represents the bone ash. The weight of the matrix was obtained by subtracting the bone ash weight from the dry whole bone weight, and the bone ash percentage calculated by dividing the bone ash by the dry weight of the whole bone. The weights, measurements and other statistics are shown in Table 1.

present at the studied interval after irradiation.

GROWTH FROM PROXIMAL AND DISTAL ENDS OF THE RAT FEMUR

The amount of bone growth which takes place at the two ends of the femur after birth is known to be different. This has been demonstrated in goats (Bisgard[5]), dogs (Haas[26]), and humans (Digby[20]). In all of these, it has been shown that most of the

TABLE I

BONE ASH PERCENTAGE DETERMINATIONS

Rat No.	Sex	Dose and Age	Autopsy Age	Length		Dried Weight Femur		Bone Ash		Matrix		Bone Ash Per cent	
				R	L	R	L	R	L	R	L	R	L
85	F	1500 r at 11 days	8 mo.	22.0	33.5	.2431	.3779	.1626	.2515	.0805	.1264	66.9	66.6
93	M	1000 r at 1 mo.	6 mo.	30.0	37.0	.4860	.6195	.3262	.4155	.1598	.2040	67.1	67.1
91	M	750 r at 1 mo.	6 mo.	35.5	39.0	.5846	.6294	.3914	.4197	.1932	.2097	67.0	66.7
74	F	150 r at 4½ mo.	12 mo.	33.5	34.5	.3936	.3952	.2669	.2674	.1267	.1278	67.8	67.7
X Control	F	No treatment	4 mo.	32.0	32.0	.3742	.3762	.2478	.2503	.1264	.1259	66.2	66.5

Data obtained from dried, fat free rat femora. The right femur of the first three animals was stunted by irradiation. The last two animals were controls. In all, the bone ash percentage for irradiated and non-irradiated femora is the same.

Analysis. In the first three animals (stunted femora), there is a distinct difference in length, dry weight, matrix, and bone ash between the treated and untreated bones. In rat No. 74, in which no stunting occurred, and in rat X (untreated) there was no difference in the two sides.

Although all weights and measurements are dissimilar on the treated and untreated sides, the bone ash percentage (bone ash divided by the dry weight of the bone) is the same for each pair of femora. There is agreement to within three-tenths of 1 per cent, which is well within the limits of experimental error.

This is interpreted as showing that although bone growth was retarded and obviously modified, no demineralization was

postnatal growth is contributed by the distal growth center.

The differential growth in rat femora has never been determined. In order to permit accurate measurement of the stunting which follows irradiation, and in order to determine what effect, if any, the irradiation exerts upon the growth activity of the untreated portion of the bone, the following experiment was carried out:

Two litters of rats between two and three weeks of age were used. Under nembutal anesthesia and sterile precautions, a hypodermic needle was introduced into the medial aspect of the middle third of each femur. The hypodermic needle was introduced just far enough to penetrate the cortex. A tiny, sharply pointed fragment of steel was

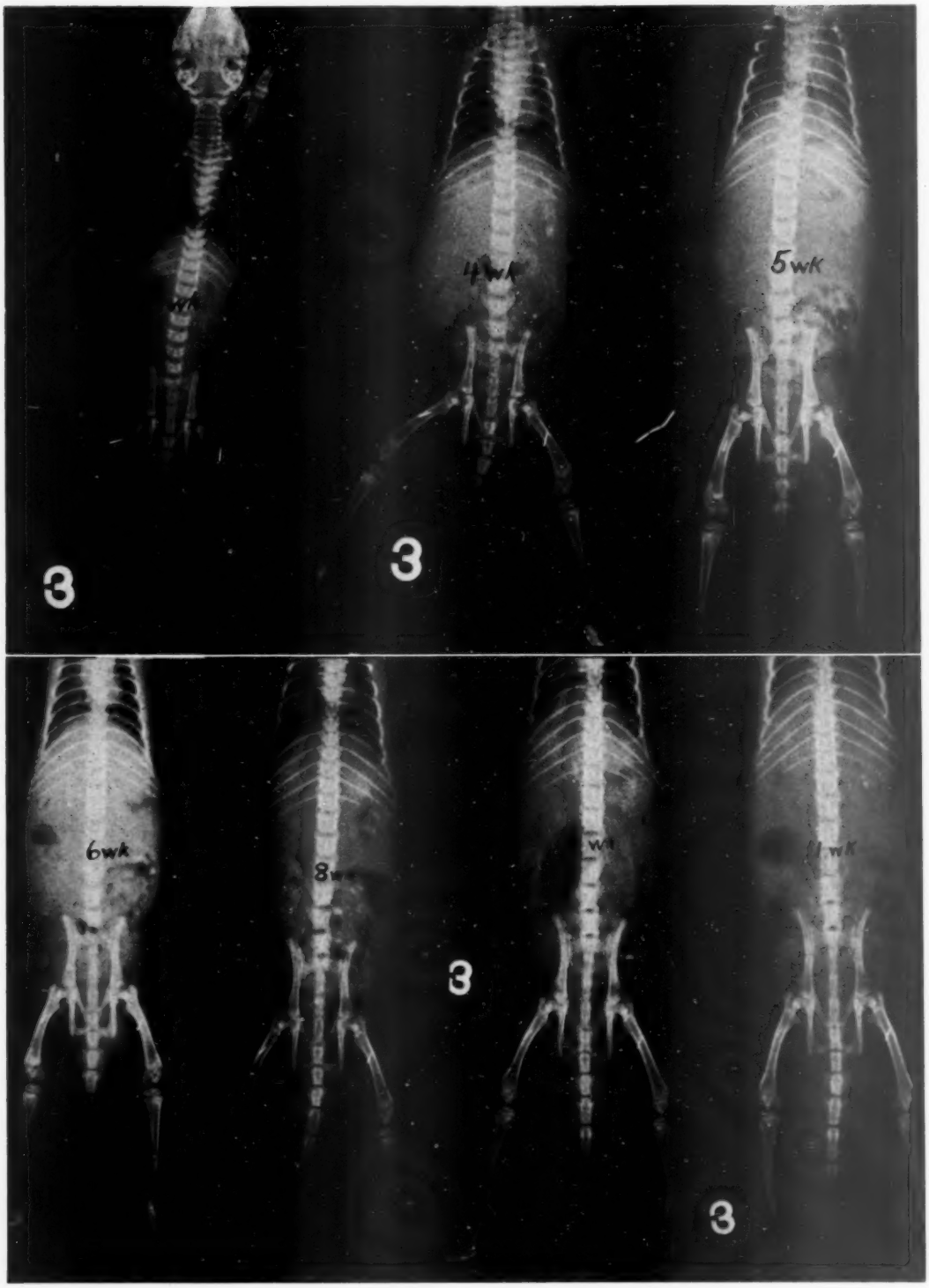


Fig. 12. *Fixed Metal Markers.* Some serial films of rat No. 303 after irradiation. The metal pins were placed in the femora at two weeks of age. The right distal femoral epiphysis was irradiated (700 r) at one month. Bone growth proximal and distal to the pins, as well as minimal stunting of the distal right femur, are shown on the subsequent films.

then injected through the needle by means of a strong wire stilette, with sufficient force to imbed it in the bone. The needle and stilette were then withdrawn, and the position of the steel marker was confirmed by anteroposterior and lateral roentgenograms. On all films at subsequent dates, the sharp metallic fragment in each femur was considered the stationary reference point, and measurements were made proximally and distally from it (Fig. 12).

In order to guard against the possibility that the pins themselves might act as irritants and cause some disturbance in bone growth, two rats from each litter had similar metallic markers placed in only one femur. Serial films showed no evidence of asymmetrical growth. All of the animals so studied showed no significant deviation from the normal femoral growth curves which have been previously determined (Fig. 2).

All the animals were followed for three months, during which time numerous films were made. Of the increase in length which took place during this period, 73 per cent was contributed by the distal epiphysis, showing that growth here is more than twice as rapid as that at the proximal end of the bone. This agrees closely with the previously determined values in other animals.

This information concerning the growth rates of the proximal and distal ends of the femur aids greatly in the analysis of all of the post-irradiation growth curves shown in this work. The experiments show that between the ages of one to six months the proximal growth center contributes only about 4 or 5 mm. to the total increase in length (Fig. 13). This enables one to estimate the actual growth activity of the distal epiphyseal regions of the heavily treated animals shown in many of the charts. If the growth centers in the irradiated portions had been seriously injured or permanently inactivated, the curve for femoral length would be almost flat, as is that of the proximal extremity (Fig. 13). Since the curves subsequent to irradiation show fairly steep slopes, it must be evidence of growth return in the treated centers.

STUNTING EXPERIMENTS ON FEMORA CONTAINING METAL MARKERS

Two litters of animals into whose femora metallic markers had been placed, were subjected to quantities of radiation slightly in excess of the minimal stunting dose. The rays were applied to the distal epiphyseal region in the usual manner. One litter was treated at four weeks and one litter at six weeks of age.

Roentgenograms were made of each animal twice a week for a month, and less frequently thereafter. Measurements were made of the total femoral lengths, and of the proximal and distal lengths, measuring in each case from the sharp point of the metallic marker.

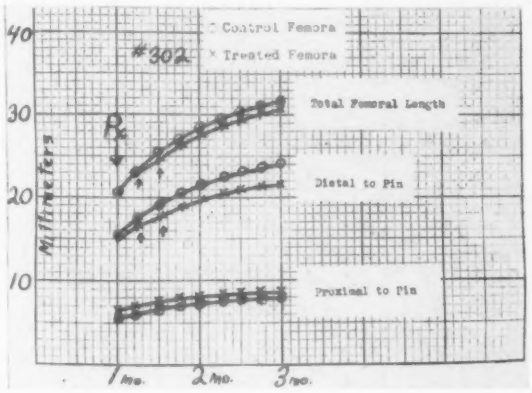


FIG. 13. *Bone Growth Proximal and Distal to Fixed Markers.* Growth of portions of femora proximal and distal to the metallic markers. This animal received 700 r at one month of age. Small arrows indicate a plateau of retarded growth of the distal right femur. Growth proximal to the pins is slow and uninfluenced by the irradiation.

The measurements of a typical animal are shown in their ordinary graphic and log-reciprocal relationships in Figures 13 and 14. It can be seen that growth at the distal end of both femora is more rapid than the proximal growth, and the slope is correspondingly steeper. Seven days after irradiation, the growth slope of the treated distal segment is flattened for ten days. It then again begins to rise at a rate practically identical with that of its control. The proximal segments of the treated and

untreated femora remain parallel to each other and are apparently uninfluenced by the irradiation. While both charts are made from the same data, the plateau of growth retardation is more readily seen in Figure 14.

This experiment indicates that the effect of irradiation is limited to the portion of the

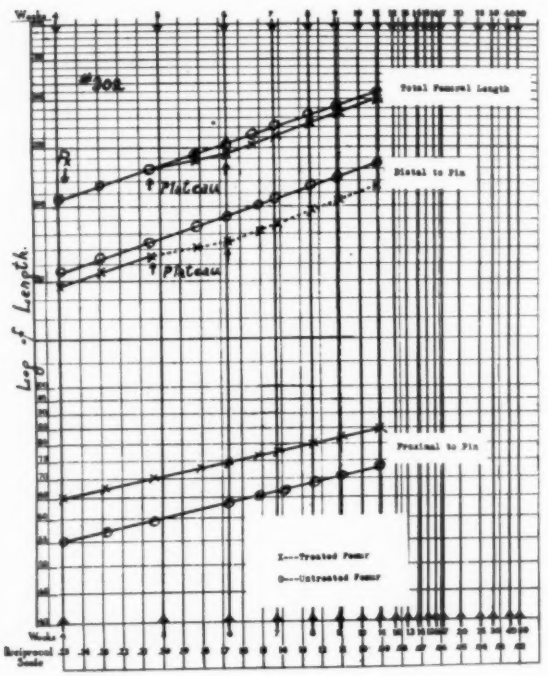


Fig. 14. *Rat No. 303. Log-Reciprocal.* Same data from Figure 13, plotted as log-reciprocal, magnifies the plateau (arrows) and illustrates resumption of the normal growth slope.

bone within the exposed field. Using doses of this magnitude, after a brief latent period there is temporary retardation followed by return of growth following a relatively short interval.

PATHOLOGY

All animals were studied by section of their bones at the conclusion of the experiment. The microscopic anatomy will be described in a subsequent report. It may be said, however, that microscopic confirmation of growth return in the irradiated bones was found. Since it is of clinical importance, it should also be mentioned that months following irradiation of young animals with moderate dosage, practically no traces could be found of the injury to the epiphyses which were stunted as above described. In older animals which received adequate irradiation to produce gross stunting, residual cartilage and bone changes were present many months later, and in some there was microscopic evidence of complete sterilization of the epiphyseal cartilage zones.

CLINICAL APPLICATION

It has often been noted that following radiotherapy in growing children, some soft tissue wasting and retardation of bone growth results where epiphyses are included.[18,54] This has been regarded as a justifiable side effect in most cases of malignant tumors, and a phenomenon to be avoided in the treatment of benign conditions.

It has been pointed out that following some fractures,[7,8,38] or resulting from certain aneurysms,[33] infections,[53] hemangiomas,[59] tumors,[27] and congenital hemihypertrophy,[41] there is excessive growth of one extremity. In other fractures and following certain diseases, such as anterior poliomyelitis, there is bony asymmetry resulting from subnormal growth of one extremity.[30]

Although as yet no clinical application of the principles outlined in the foregoing work has been attempted, it seems possible that this method may be useful in certain situations, as a means of equalizing the lengths of asymmetrical bones in young subjects.*

Bone lengthening procedures, whether direct orthopedic (Shands and Raney[51]) or sympathetic nervous nature (Carrell[12]) (Harris[29]) (Pearce and Morton[42]), are often difficult and unfortunately unpredictable as to outcome.

* Since the preparation of this manuscript a paper entitled "The effect of x-ray therapy for closure of the epiphyses" was read by Dr. David Spangler of Dallas, Texas, at the Twenty-sixth Annual Meeting of the Radiological Society of North America, Cleveland, Ohio, December 2–6, 1940 (*Radiology*, 1941, *37*, 310–315). This paper deals with the clinical problem of therapeutic limitation of bone growth.

Bone shortening operations or epiphyseal destruction by surgery are irreversible and must be done at the proper time to be of value. The danger of overshortening is always present.

It appears only logical, when dealing with unequal extremities, to suggest the possibility of the therapeutic use of roentgen-ray retardation of the longer bone in order to permit the shorter one to "catch up." In addition to the obviation of an operation, there is the advantage that growth would presumably be resumed after the recovery, as has been shown to take place in the stunted rat femora. For this reason the irradiation could be administered at practically any age with little fear of overshortening.

SUMMARY

Seventy-three per cent of the postnatal femoral growth in albino rats takes place at the distal extremity of the bone. This is comparable to the growth at the distal end of the human femur. The growth rate is such that there is a constant relationship between the logarithm of the bone length and the reciprocal of age.

Roentgen rays applied to the growing epiphyseal region produce quantitatively predictable degrees of stunting ranging from temporary retardation to permanent cessation of growth, depending upon the dose administered. The amount of radiation required to produce minimal stunting bears a linear relationship to the age of the animal treated. It cannot be correlated with the rapidity of growth or skin effect.

As judged by gross measurements of length, controlled radiation stunting is temporary. After a latent period, there is diminution of the growth rate, but measurable growth soon reappears. The slope of the growth curve (log-reciprocal comparison) after the period of retardation parallels that of the untreated femur. Young animals recover more quickly than older animals and can tolerate quantities of roentgen rays far in excess of the minimal stunting dose.

Months after irradiation with large doses, there is no evidence of bony decalcification as determined by bone ash percentage values. Microscopic studies show a return to normal cartilage and bone architecture, and absence of permanent marrow or blood vessel injuries in young animals.

This method involving artificial retardation of bone growth may prove to be applicable for clinical usage when it is deemed advisable to equalize the lengths of asymmetrical bones. It should prove to be a valuable biological means of studying the effect of roentgen rays upon the living cells of complex organisms, and another method for use in the study of the physiology of bone growth.

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GRANULOSA CELL CARCINOMA*

REPORT OF TWO CASES

By A. M. GNASSI, M.D., J. B. FAISON, M.D., *and* M. FELLMAN, M.D.
JERSEY CITY, NEW JERSEY

TWO cases of granulosa cell carcinoma are presented with emphasis on their rapid termination and their behavior to irradiation.

REPORT OF CASES

CASE 1. Mrs. M. K., white, aged forty-two, entered the Medical Center November 6, 1936, complaining of vaginal bleeding. The onset of symptoms was in the first week of October when the patient experienced frequency of urination, and nocturia without pain or burning on voiding. Vaginal bleeding began on November 1, 1936, one week after her regular menstrual period, and persisted intermittently until her admission. On November 3, the patient had profuse bleeding and passed several blood clots. She consulted her physician who discovered a lower abdominal tumor and advised hospitalization. She has had no pain since onset of present illness but marked loss of appetite and constipation. She has lost no weight. Her menstrual history began at sixteen with a cycle of twenty-seven days and lasting four or five days without any pain or discomfort.

The past history was negative except for the usual childhood diseases. The patient had two normal, spontaneous home deliveries without complications; both children are living and well. Her father died of an unknown cause at an early age; her mother is living and well.

Physical examination revealed a well nourished, well developed female who did not appear acutely or chronically ill. No abnormalities were noted in the breasts. The abdomen was slightly distended; no shifting dullness was noted. In the lower abdomen was a large firm, smooth, fixed mass which filled the left iliac region and extended downward into the pelvis, slightly to the right of the midline. The mass was not painful or tender. Pelvic examination showed a dark brown vaginal discharge. The cervix was irregular, firm with several healed lacerations. The uterus was enlarged and nodular and rather firmly fixed. The mass, felt abdominally, was contiguous with the uterus but a definite groove was felt between the mass and the uterus. The preoperative diagnosis was fibromyomatous uterus. The laboratory findings: red cell count, 4,700,000 hemoglobin 90 per cent (Tallqvist), white cell count 12,050; differential, 76 per cent polymorphonuclear leukocytes, 24 per cent monocytes. The sedimentation time was 18 mm. in forty minutes. Other clinical laboratory findings were essentially negative.

On November 13, 1936, a bilateral salpingo-oophorectomy was performed. The uterus was firmly fixed to the pelvis and very nodular. There were noted numerous firm nodular areas in the pelvic peritoneum, varying in size from that of a pea to that of a lima bean. Both ovaries were similar in appearance, one measured 9.5×7×6 cm. and weighed 150 grams, and the other measured 10×7×6 cm. and weighed 145 grams. The serosa was smooth and glistening. The surfaces were irregular, firm, and yellowish white with several thin walled cysts 1 to 2 cm. in diameter. The cut surface was solid, firm, yellowish-white and finely honeycombed with multiple cysts varying from 0.5 to 2.5 cm. in diameter. Their contents were clear and yellow, and their lining thin, smooth and glistening, except for small areas where it was thicker, and of finely granular yellowish friable tissue. Closely attached to each ovary was a tube 5.5 cm. in length and varying from 0.5 to 1.0 cm. in diameter. Their surface was hard and finely nodular, but covered by a smooth serosa. On the cut surface, the lumen was narrowed, the muscularis was moderately thickened, and the subserosa markedly thickened, firm, and yellowish white. The patient had an uneventful postoperative course.

The microscopical diagnosis was bilateral granulosa cell carcinoma with metastases to tubes, uterus, pelvis, and bladder.

On discharge on November 30, 1936, and until May, 1937, the patient was given radiation therapy as follows: 450 r×2, five portals, 200 kv. at 50 cm. distance, 0.5 mm. copper filter. After each treatment there was loss of appetite,

* From the Departments of Pathology, Malignant Diseases, and Surgery, Medical Center, Jersey City, New Jersey.

weakness and patient had to go to bed for long intervals. The subsequent course was progressively worse with development of ascites and cachexia until July 21, 1937, when the patient died. The total duration from the onset of the first symptom was ten months.

Case II. Miss M. B., white female, aged twenty-one, was admitted to the Medical Center, April 30, 1937, complaining of pain in the right thigh with radiation down the left, of three months' duration. From the third week of March, the patient experienced occasional abdominal pain, swelling of the abdomen, loss of appetite, and constipation. On April 27, there was retention of urine. She was twice catheterized by her doctor before admission. Her last menstrual period beginning April 6, was regular. On April 26, she started bleeding a little for a few days.

Her past history was negative except for childhood diseases. Her parents are alive and well. Her menses had always been regular; they started at the age of thirteen, cycle of thirty days, and lasted four days.

Physical examination revealed a poorly nourished and developed white female who looked chronically ill. Her abdomen was tense and resembled a full term pregnancy. On pelvic examination a large cystic mass was found on the left side; there was no pain or tenderness. The cervix was essentially normal; the adnexa were not felt. This mass was believed to be the bladder and after catheterization of 1,100 cc. of fluid, the abdominal mass flattened and the pelvic examination at this time disclosed a large hard immovable mass on the left side of the pelvis. The cystogram in anteroposterior and lateral positions revealed the bladder to be displaced anteriorly and upward by a pelvic mass. The laboratory findings: red cell count 4,350,000, hemoglobin 90 per cent (Tallqvist), white cell count 14,000; differential, 80 per cent polymorphonuclear leukocytes, 19 per cent lymphocytes and 1 per cent eosinophils. The urine showed three plus albumin, specific gravity 1.012, three red cells per high power field, eight pus cells per high power field, and a few epithelial cells. The remainder of the clinical laboratory work was negative.

On May 6, 1937 a laparotomy was performed. From the operative note by Dr. Fellman: "Filling the pelvic cavity and pushing upwards on the right side was a large hard mass which displaced the bladder to the right and slightly upward. The sigmoid was adherent to the mass and pushed to the right side. A lemon sized nodular mass protruded from the under surface of the left lobe of the liver. A large biopsy of the tumor was taken and the abdomen closed." The microscopical diagnosis was granulosa cell carcinoma.

The postoperative course was marked by continued low grade temperature for one month. The abdominal mass extended to the umbilicus. Before discharge on August 30,1937, patient was given transfusion of 500 cc. of whole blood. Before readmission on September 29, 1937, she was given roentgen therapy as follows: 200 kv. at 50 cm. distance, 0.5 mm. copper filter, 350 r×2 through five portals: right and left pelvis anterior, right and left pelvis posterior, and midline position. After readmission, because of swelling of the abdomen, abdominal paracentesis delivered 5 liters of blood-colored fluid on October 4, and 7 liters on October 22. Her condition grew worse and she died on October 31, 1937. The total duration from the onset of symptoms was ten months, with a lapse of six months after treatment was started.

DISCUSSION

Much has recently been written on the etiology and symptomology of this tumor. Suffice it to say that it very likely arises from undifferentiated unused sex cells of the ovary. These cells, under unknown conditions, may differentiate to assume characteristics which histologically resemble the seminiferous tubules of the testis, this giving rise to the defeminizing tumor or arrhenoblastoma. On the other hand, they may differentiate to resemble the granulosa cell of the ovarian follicles leading to the formation of the so-called granulosa cell tumor.

The symptoms of the granulosa cell tumor are chiefly due to hypersecretion of folliculum and therefore are hypertrophy of the breast, uterus, cervix, and endometrial hyperplasia. If the tumor occurs in a young girl, it will lead to precocious puberty; after menopause, rejuvenation and reappearance of a pseudomenstrual cycle. During the reproductive time, bleeding and ovarian masses are the most conspicuous signs. Other symptoms are not unlike those of any pelvic tumor.

FIG. 1

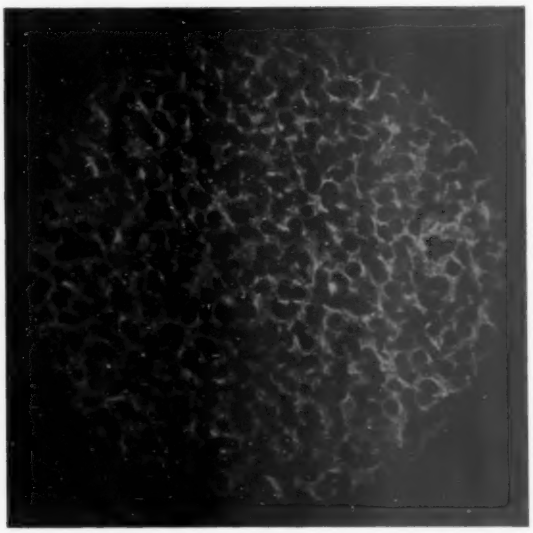

FIG. 3

Pathology. Gross: Usually only one ovary is involved. They vary in size from a few millimeters in diameter to huge proportions. They are ovoid in shape or uniformly enlarged; as a rule, smooth, but they may be lobulated. The great majority are solid but some may be permeated by many small cysts; rarely are large cysts formed.

Microscopical: Histopathologically (Case 1) they assume a variety of forms such as folliculoma as seen in Figures 1 and 2, as solid masses (Fig. 3), and occasionally an adenomatous arrangement (Fig. 4). The stroma varies from fibrous tissue (Fig. 5) to myxomatous tissue (Fig. 6).

In the more undifferentiated tumor (Case 11) the cells are round with indistinct cellular membrane, granular foamy cytoplasm, centrally placed round or oval nuclei moderately rich in chromatin. Occasionally the cells form follicles (Fig. 7). The stroma is scanty and in places hyalinization is seen.

FIG. 2

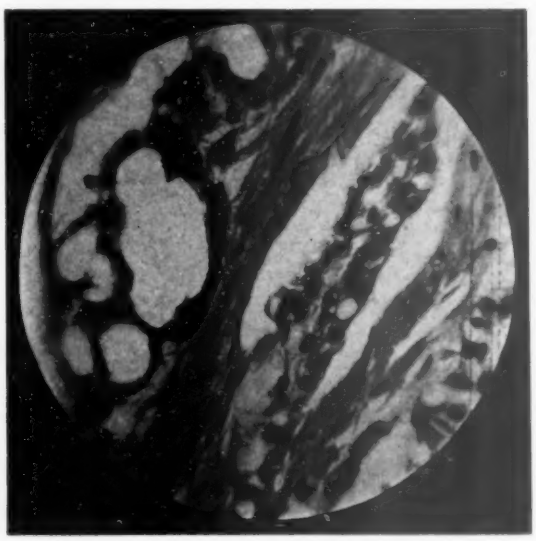

FIG. 4

In this type, mitotic figures are found, one in every three high power fields. Most of the tumor is composed of diffuse masses moderately permeated by follicular structures. The blood vessels are present in moderate number.

Prognosis and Treatment. Granulosa cell carcinomas are usually unilateral. They grow slowly and are of a low degree of malignancy, but in a certain percentage of the cases, they have a tendency to recur, become implanted in the pelvis, peritoneum, and give metastases to the liver.

Fig. 5

The histopathological picture is, in some cases, not clearly related to their degree of malignancy, as they may be histologically benign but clinically malignant. Our cases, especially Case 1, are not histopathologically rapidly growing tumors, yet their clinical course leaves no doubt as to the degree of aggressiveness. Any localized granulosa cell carcinoma of a low degree of microscopic malignancy, which is completely removed, gives a good prognosis.

Surgery, irradiation, or a combination of the two methods are means at our disposal.

Granulosa cell carcinomas are usually considered radiosensitive. Their regression, however, is a temporary one, because they may recur and death follows in a short time.

Fig. 6

Partial surgery followed by irradiation is not recommended because the disturbance of blood supply, with the inevitable fibrosis ensuing from surgical intervention, renders the tumor resistant to irradiation. Complete surgical excision offers the best prognosis. As a palliative measure, cases with advanced metastases will do much better with radiation therapy.

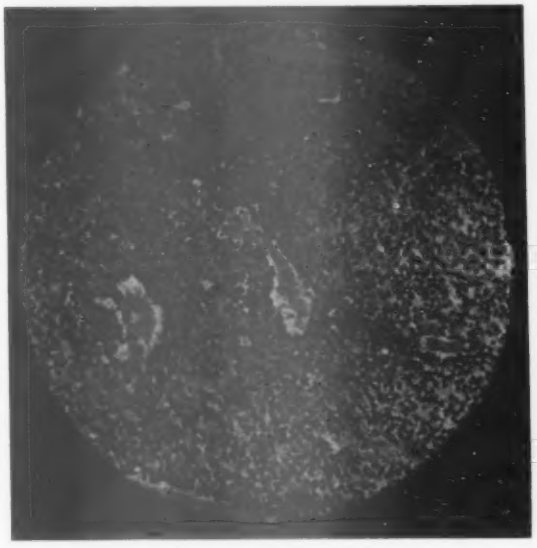

Fig. 7

SUMMARY AND CONCLUSIONS

1. Two cases of rapidly fatal granulosa cell carcinoma with metastases in women during the reproductive age are presented.

2. These tumors may occur at any decade of life, and usually after the menopause.

3. They are unilateral, rarely bilateral, and relatively benign.

4. The microscopical pattern does not always support the usual clinical behavior.

5. Complete surgical excision of the tumor offers a very good prognosis in the vast majority of the cases.

6. Granulosa cell carcinomas may metastasize to the perineum, peritoneum, liver, and rarely to the skeletal muscle.

7. They are sensitive to irradiation but they recur and death follows in a short time.

8. Fibrosis, necrosis, inflammation, and disturbances of the blood supply greatly reduce the palliative effect of irradiation.

VOL. 47, NO. 3

BASAL CELL EPITHELIOMA

A CONCEPT OF ITS HISTOGENESIS*

By IRVING N. HOLTZMAN, M.D., *Associate Dermatologist*
and
HERMAN BOLKER, M.D., *Pathologist*
Brooklyn Cancer Institute
BROOKLYN, NEW YORK

THE present concept of development of a typical squamous carcinoma of the skin is one of progressive proliferation, over a varying period of time, of a cancer cell through a stage where its colony is strictly intra-epidermal to final invasion of the corium.[16] The origin of the cancer cell is still the great unknown of medicine. Still, one feels a substantial measure of progress has been attained with the development of the theory of somatic mutation or genetic alteration of a cell which subsequently proliferates at a constant rate which is more rapid than the normal. The lesion will appear clinically when environmental changes allow the progeny of this cell to remain alive after reproduction and gradually replace the normal surrounding tissue elements.[3] It is a peculiar paradox, however, that the basal cell epithelioma presents, histopathologically, a type of growth which, from its inception, is apparently uncircumscribed and invasive, growing downward into the corium and permeating lymphatics, yet clinically is benign; practically never metastasizes,[13,15] and threatens human economy only by its local erosion. Because of this discrepancy between histopathological appearance and clinical course, it was deemed advisable to undertake a study of the basal cell itself with a view to ascertaining what pecularities inherent in this cell might explain the unusual characteristics of its illegitimate offspring, the epithelioma.

The basal cell has two accepted collateral lines of development. Embryologically it forms:

1. Pavement epithelium of skin—epidermis, with all its layers.
2. Skin appendages (sudoriparous glands and pilosebaceous apparatus).

At birth practically all the sudoriparous glands are pre-formed[12] so that during life the basal cell continues, with this exception, all its other developmental functions.

A classification of tumors of the skin would logically be based on the following fundamental premises:

1. That there is a genetic mutation of the ancestral basal cell with a resultant increased rate of mitosis. This mutation may be minimal, moderate, or marked.
2. That, with the increased rate of reproduction, the cells will proliferate in one direction, i.e., corresponding to the polarity of the ancestral basal cell at the time it underwent mutation.

anaplasia

CLASSIFICATION

Basal Cell

- I. Upward polarity[16] (epidermis formation)
  - A. Keratoses, leukoplakia, senile verrucae, etc.
  - B. Intra-epidermal epithelioma (including Bowen's, Paget's types).
  - C. Squamous carcinoma.
- II. Downward polarity (appendage formation)
  - A. Adenoma sebaceum.
  - B. Syringadenoma.[17]
  - C. Epithelioma adenoides cysticum.
  - D. Nevo-epithelioma adenoides (cylindroma).
  - E. Superficial basal cell epitheliomatosis.
  - F. Basal cell epithelioma.

Such a classification does not necessarily exclude the possibility of more than one type of mutation in the same individual. This would explain the occurrence of mixed

* From the Department of Hospitals, New York; Brooklyn Cancer Institute, William E. Howes, Clinical Director.

type of epithelioma—also the occurrence of typical basal cell epithelioma in association with one of the more benign types. Histopathologically, the concept of precancerosis[2,16] is only tenable if one agrees that cells which have undergone mutation are susceptible to further mutation by physical agents (roentgen rays, chemicals, actinic radiation[11,14]), phenomena which have been demonstrated only experimentally.

BASAL CELL EPITHELIOMA

There are several cytological characteristics of the basal cell layer of human skin

FIG. 1. Photograph illustrating cohesion of cells. (Reproduced with permission from Chambers and Rényi.[4])

which are rarely emphasized, which to our mind, explain quite readily the morphologic paradox of the basal cell epithelioma mentioned in the introduction. There has always been a tendency to consider the basal layer as a row of individual cells. This concept is naturally the result of examination of stained preparations. Actually, the basal layer is probably a continuous protoplasmic mass[12] containing nuclear units. The so-called membrane is the ectoplasm and is a common continuous connection between adjoining nuclear units. With proliferation upwards, to form the pavement epithelium, vacuolization takes place in this ectoplasm leaving, at regular intervals, the so-called intercellular bridges.[10] The demonstration of fibrils moving from one cell to another through these bridges,[5] indicates the continuity of these cells—most marked in the basal layer, and diminishing as one approaches the corneal layers where cohesion has completely disappeared.

This continuity has been demonstrated beautifully in vivo.[4] Using the technique of microdissection, it was shown that the cells of the deeper layers of human skin could be separated only with the use of extreme tension, whereas the cells of the superficial layers could be easily teased apart. In fact, this marked cohesion seemed to be peculiar to the skin, since the cells of several other epithelial organs and membranes did not possess it. When three adjoining basal cells were isolated and kept in a nutrient medium, injury to one of these cells with resulting nuclear coagulation was followed within a short time by a similar change in the other two, again demonstrating continuity of protoplasm. In the basal cell epithelioma, the histopathological picture of the cell nests shows no evidence of cellular demarcation. Obviously this continuity or cohesion of cells, inherent in the normal basal

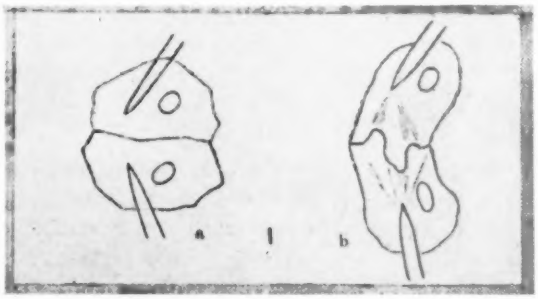

FIG. 2. Diagram of Figure 1.

cell, is retained in the basal cell epithelioma. One is confronted, then, with a neoplasm which, as it grows, retains connection with the original point of origin giving a picture resembling the roots of a tree. This is confirmed by reconstruction of serial sections of these growths. This protoplasmic continuity explains the absence of metastasis. In the squamous type of epithelioma, metastasis takes place as soon as the intraepidermal growth buckles through the

basal layer into the corium,[16] because of diminished cohesion of cells.

The presence of a basement membrane can be explained simply by the protoplasmic continuity of the proximal ends of the basal cell. The presence of lymphatic permeation raises an interesting question. The ease with which the cell cords of a basal cell epithelioma enter the pre-formed lymph capillaries indicates the extreme permeability between terminal capillaries and intercellular tissue spaces. All the recent descriptions of the lymphatics state that the lymph capillaries are closed.[1,6,7,9] If this were the case, an invasion of these vessels could be accomplished only by breaking through the endothelial lining. One must admit that invasion of the blood capillary should be equally possible. In fact, the existence of a positive pressure within the blood capillary would make erosion from without much easier. Actually, at least in skin neoplasia, invasion of blood capillaries is very rare. In other words, invasiveness or infiltrability of a tumor is not the determining factor of malignancy from the standpoint of metastasis, rather the cellular continuity and cohesion of the growth.

Several workers have disputed the origin of basal cell epithelioma from the basal layer of the skin.[8] They claim that these lesions are all hair-matrix carcinomata and insist that actual demonstration of origin of these tumors from the basal layer of the skin cannot be accomplished. We agree that the basal cell epitheliomata are tumors of appendage-forming character; also that origin from hair-matrix is possible. In fact, only where appendage formation occurs during life does one see basal cell epitheliomata. These lesions are never seen in the palm or soles[8] where there are no hair follicles and where the sweat glands are all preformed by birth. However, the origin of basal cell epithelioma from the basal layer of the skin may be accepted for the following reasons:

1. Actual demonstration of this origin is present in the superficial type of epithelioma.
2. At the point of origin of a basal cell lesion the nest of cells within the papillary lymphatic will compress the blood vessels of the papilla. The early stage of this compression is seen in the common finding of prominent dilated vessels in the pearly border. As compression increases, ischemia develops, followed by ulceration, so that the original source of the neoplasm is lost in inflammatory exudate and necrosis and no longer is demonstrable.
3. It is generally accepted that neoplasia is most common where mitosis is most active. In the skin and its appendages, the area of greatest mitotic activity is in the basal layer.[16]

CONCLUSIONS

Basal cell epithelioma presents the following dynamic picture:

1. Genetic mutation of a basal cell with appendage-forming polarity.
2. The increased rate of mitosis results in downward infiltration of the cell colony into tissue spaces and lymphatics with permeation of the superficial lymphatic plexuses of the skin.
3. The absence of metastasis in spite of the presence of neoplastic tissue in the lymph capillaries is attributable to the marked inherent cohesion (or continuity) of the protoplasm of these cells.

We are indebted to Miss Dorothy Weinstein for her technical assistance in preparation of serial sections.

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GAMMA RADIATION FROM AIRPLANE INSTRUMENTS*

By ROBERT B. TAFT, M.D., B.S., M.A., F.A.C.R.
Professor of Radiology, Medical College of the State of South Carolina.
CHARLESTON, SOUTH CAROLINA

DURING last summer, the following appeared in a metropolitan daily newspaer: "Take it for what it's worth, but a scientist asserts there's enough radium radiation from the fluorescent dials of the instrument panel in a great modern airplane to miss by only a slender margin giving a pilot a lethal dose if he remains in his seat an average of four hours a day over a stretch of three or four years."

This statement, though seeming improbable, caused some concern among pilots and appeared worthy of investigating. Accordingly, I conducted tests in airliners at the Charleston, South Carolina, Municipal Airport. A small battery operated Geiger-Müller counter[1] was carried into the passenger compartment of a Lockheed Electra NC 14992 where the background count was found to be 9 per minute, showing that there was no interference from any source such as radium being in the mail compartment. Following this, the instrument was carried into the pilots' compartment where the count greatly increased. As the counter approached the instrument panel, very rapid impulses were noted, the bank indicator showing the greatest activity. When placed in the lap of the pilot occupying the customary seat the rate was found to be 93 per minute. A similar test on a Douglas DC3 NC 15598 showed a count of 103 per minute. There are a few more instruments with luminous dials in the transatlantic ships than in either of the ships tested but this equipment was not available in time for this report and no great difference would be expected.

Subsequently, in the laboratory, a known sample of radium was experimentally arranged at such a distance that a similar count was obtained. These conditions were met when 12.5 mg. was placed 30 feet (914 cm.) from the instrument.

It is generally accepted[2] that 1 mg. of radium gives 8 roentgens (approximately) per hour at a distance of 1 cm. With this information it is calculated that under the above conditions, the instrument was receiving 0.00012 r per hour. As a line pilot is permitted to fly only eighty hours per month (960 hours per year), the dose received would be 0.115 r per year.

As it is now conceded that a radium worker may receive 0.1 r per day and remain in good health,[3] one may realize that the dose of radiation received by the pilot is not a dangerous amount.

Indebtedness is expressed to Delta Airlines and Eastern Airlines for their cooperation and to Mr. Carl B. Braestrup for having checked these figures and methods.

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DISCUSSION

DR. ARTHUR H. COMPTON, Chicago. That the results obtained by Dr. Taft are reasonable and indicate no dangerous exposure to radiation is indicated by the fact that the normal ionization to which a person is subject from combined cosmic rays and gamma rays from rocks amounts roughly to two-tenths of a roentgen per year.

* Read at the annual meeting of the American Physical Society, Philadelphia, Pa., Dec. 26, 1940.

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Twenty-seventh Annual Meeting: Haddon Hall, Atlantic City, N. J., June 8–9, 1942.

EDITORIAL

THE EARLY DIAGNOSIS OF VENOUS THROMBOSIS BY VENOGRAPHY

VENOGRAPHY, in the light of recent investigations on venous thrombosis by Bauer,[1] assumes added importance as a diagnostic procedure. There are numerous reports in the literature dealing with the successful visualization of the venous system, particularly in the extremities. This method of study was not greatly used, however, until the advent of the various iodide solutions that permit of successful urography. Following the introduction of these preparations many investigators have added to our knowledge, notably Egas Moniz, Dos Santos, McPheeters and Rice,[2] Barber and Orley,[3] Veal and McFetridge,[4] Barker and Camp,[5] Dougherty and Homans,[6] and others.

With the simplicity of the method, as outlined by Dougherty and Homans, and the apparent safety of the procedure not only have we gained a considerable amount of knowledge concerning the normal physiological flow of the blood in the venous channels of the extremities but also regarding the formation of venous thrombi. Contrary to what was generally thought for a long time, namely, that the process giving rise to large thrombi started in the large pelvic veins or in the uppermost portions of the femoral veins, we now know from the work of clinicians and pathologists, particularly Homans, Rössle, Neumann and Frykholm, that the starting point of the thrombotic process in a large percentage of the cases is in the veins of the lower part of the leg, and venography has enabled a more thorough study of this condition.

The early diagnosis of venous thrombosis has become more important since the introduction of heparin in the treatment of thrombo-embolic disease. Bauer, in his recent article, calls particular attention to the use of heparin in the treatment of this disease and to the part that venography plays in its early diagnosis. From a study of his cases he became impressed with the fact that the treatment of thrombosis should begin at a much earlier stage, namely, immediately after the very first manifestation of the disease has appeared. The best results are obtained with the treatment if it is given not to patients that have thrombosis but to those who are just getting it, and the surest method of determining this point is by means of venography. He found that by venography new light was cast on many phases of the problem of thrombo-embolism. From the use of this method of examination Bauer has come to the conclusion that the whole process of thrombosis starts with the clot which arises from some unknown reason, protruding from a muscle vein into the lumen of one of the thick venous trunks of the lower part of the leg. It becomes a starting point of a deposition thrombus, which subsequently goes on growing in the direction of the blood stream. This earliest first stage can be demonstrated by venography though it will doubtless evade recognition by other methods. In the next stage the large veins in the lower part of the leg are progressively filled,

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the thrombotic masses in the course of time completely filling the lumens and becoming firmly attached to the walls of the vessels. Concurrently, there proceeds a longitudinal growth up through the femoral vein. This thrombotic structure forms, as it were, a cast of the great vein's lumen, though it does not completely occlude the latter. The wall of the vein is as yet not involved in any way, and the thrombus is anchored only at its lower end, far down in the lower part of the leg. This condition appears to be more common than was formerly supposed and cannot be diagnosed by ordinary clinical methods. By venography an earlier diagnosis of a thrombus can be made than by any other method.

To insure this early diagnosis, however, Bauer calls attention particularly to the necessity of carefully watching the clinical manifestations and symptoms of the patient and not waiting until the symptoms of thrombosis are clear cut. Great attention must be paid to the slightest unexplained rise in the pulse rate or temperature or to the general restlessness of the patient and to such transitory signs of aching of the legs, lasting perhaps only a few hours, and the slight change in the color of the skin, a small increase in the firmness of the calf muscles or a tender spot on the back of the lower part of the leg. If these earliest signs are observed and if venographic examinations are undertaken at that time, an accurate diagnosis can usually be obtained in cases in which otherwise there might be only a faint suspicion of a thrombosis. The venogram reveals an absence of opaque filling in one or all of the deep veins of the lower part of the leg which not only insures the diagnosis but provides objective evidence of the condition. Obviously in the face of these early signs of a possible thrombosis some normal roentgenograms will be obtained.

It appears from the work of Bauer that the best and most favorable results of treatment are obtained in those cases where the thrombosis is at a minimal stage. When one considers the disabling effects and the concomitant dangers of thrombosis every effort should be made to arrive at as early a diagnosis as possible and venography apparently permits of an earlier diagnosis than any other known method. By this study the earliest manifestations of the disease may be revealed when the institution of heparin therapy promises its best results.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: Atlantic City, N. J., Oct. 6–9, 1942.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Atlantic City, N. J., June 10, 1942.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N. J., June 8–12, 1942.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting, 1942: To be announced.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles County Medical Association
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Florida. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Greater Kansas City
Secretary, Dr. P. E. Hiebert, 811 Huron Bldg., Kansas City, Kansas. Meets third Thursday of each month at a place designated by the president.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society meeting. Next meeting New Orleans, April, 1942.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. Hugh F. Hare, Lahey, Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Paul C. Swenson, Presbyterian Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport. Next meeting, Necho Allen Hotel, Pottsville, Pa., May 15–16, 1942.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive. 8 P.M., Rochester Academy of Medicine Building.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho, Annual meeting in Denver, summer of 1942.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Clinic, Temple, Texas. Next annual meeting, Houston, Texas, February 7, 1942.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress.
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

THE USE OF ROENTGEN RAYS IN THE MANIPULATION OF FRACTURES OF THE EXTREMITIES*

The following is a memorandum prepared by the British X-ray and Radium Protection Committee on the dangers of surgical work under the fluoroscopic screen. The Secretaries of that Committee kindly forwarded the memorandum to the JOURNAL with permission for its publication.

X rays may be used for this purpose in two ways:—

1. By screening or taking radiographs (which can now be processed very rapidly) when the surgeon believes he has attained correct position. Radiography should be the usual procedure adopted, and should involve no exposure of the hands or person to a direct beam of X rays.
2. By actually manipulating the fracture under fluorescent screen control. This inevitably produces conditions of grave risk, and cannot be rendered safe, for the surgeon's hands must at times come into the direct beam of X rays.

Only in exceptional cases should the second alternative be adopted, and then only on the responsibility and under the direction of the senior surgeon. Such work should never be delegated to juniors.

General Conditions. The operating room should be satisfactorily darkened. Lights should be dimmed as far as possible before screening, and no lights should face the surgeon.

The previous films of the case should be seen and memorised, and not scrutinised in a bright viewing box immediately before the manipulation. It is essential that the surgeon should prepare his eyes for screening. This takes a certain amount of time, which varies with the individual, but a minimum period of five minutes in the dark should be allowed for this. It can also be attained by using a single red light in the room or by the wearing of dark (preferably red) goggles for a period of some minutes before screening is begun.

The X-ray apparatus should be operated by a radiographer who has been specially trained for this work. He should be given definite instructions by the radiologist as to the limits within which he must use the apparatus. These limits should be governed by hard and fast rules, drawn up by the radiologist in conjunction with the surgeon in charge, and not in any circumstances to be varied if a surgeon finds himself in difficulty.

The radiographer should keep a log book recording the factors with actual times of screening involved. This log book should be signed by the surgeon after each operation, and the book should be inspected at regular intervals by the radiologist.

Operating Conditions. In general the recommendations of the British X-ray and Radium Protection Committee should be followed.

The tube-screen distance should not be less than 20 or more than 30 inches.

The apparatus should be set to give not more than 65 kv. For thin parts and children a lower kilovoltage will be adequate; *3 ma. is the maximum screening current that should be used.*

As a safeguard against excessive screening current, an automatic "cut-out" can be incorporated in most X-ray sets at a small cost, which will "cut out" if the selected factors are exceeded.

All apparatus should be shock proof. An aluminium filter of 1 or 1.5 mm. should be fixed in the aperture of the X-ray tube so as to furnish a total filtration of not less than 2 mm. of aluminium. Cones or cylinders to limit the X-ray field are essential; these should be of such size that the illuminated area falls well within the limits of the fluorescent screen. An illuminated area of 5 inches circle, or 4 inches by 6 inches rectangle, is ample for this type of work. The radiographer should constantly watch to see that the X-ray beam is kept within the limits of the fluorescent screen. It is his duty to point it out to the surgeon if this essential factor is not complied with. If the X-ray tube and screen can be coupled to ensure this, it is a major safeguard which should be adopted.

An integrating time switch is useful. All exposures should be made with a timing device.

The fluorescent screen, faced with lead glass, should be of modern manufacture and in good condition. It must have handles that afford protection to the hands. A mechanical device for holding the screen is, however, preferable.

Under the above conditions screening and radiography between manipulation can be car-

* The same considerations apply to the removal of foreign bodies under X-rays.

ried out with safety, provided always that the hands of the operator or of the assistant who holds the screen or films do not come within the direct beam.

Manipulation of fractures under screen observation should only be employed in very exceptional cases, preferably, if possible, with a radiologist in attendance. The time occupied in such manipulation should be strictly limited to 1 minute, and this should be accurately computed by the radiographer in attendance. It should be recognised that, even with one rapid manipulation with the hands in the direct beam, the safety tolerance dose may be considerably exceeded. *If the surgeon is willing to take this risk, it is entirely on his own responsibility.*

(*Note.* In the direct beam the exposed hands are subject to the daily safety tolerance dose in the prescribed conditions in about 2 seconds at 20 inches. At shorter distances, e.g. when the reflecting fluoroscope is employed, the hands are nearer the tube and the dose is increased.)

The cryptoscope (the fluorescent screen fitted to the head and supplied with a hood) is a very dangerous device, and should never be used.

Operating conditions vary greatly in different hospitals, and it is suggested that each should draw up its own set of regulations. A list of specific safety instructions should be prepared and posted in the departments concerned.

CLINICAL CONFERENCE OF MID-WESTERN RADIOLOGISTS

The Sixth Annual Clinical Conference of Mid-Western Radiologists was held at St. Louis, Missouri, on February 13 and 14, 1942. The following was the program presented:

Friday, A.M., February 13, 1942
Symposium on Circulatory Disorders

Applications of the Photo-electric Plethysmograph to Clinical Circulatory Problems. A. B. Hertzman, Ph.D.
Arteriovenous Fistula. W. J. Gallagher, M.D.
Coarctation of the Aorta. F. J. Burke. M.D.
Patent Ductus Arteriosus. J. L. Mudd, M.D., and J. J. Hammond, M.D.
Circulatory Disturbance in Children. J. A Rossen, M.D.

Symposium on Neurological Conditions

Head Injuries and Their Management. Ernest Sachs, M.D.
Electroencephalography in Neurological Conditions. Carlyle F. Jacobsen and Henry Schwartz, M.D.
Neurological Indications for Spinal Myelography. Roland Klemme, M.D.
The Use of Opaque Media in the Diagnosis of Intraspinal Block. W. E. Leighton, M.D.
Roentgen Manifestations of Endocrine Disorders. A. A. Werner, M.D.
Recent Advances in Estrogenic Therapy: Ovarian Deficiencies, Breast Growths, Synthetic Estrogens. Cyril MacBryde, M.D.
Vitamin K. E. A. Doisy, Ph.D., and S. A. Thayer.

Friday, P.M., February 13, 1942
Symposium on Pulmonary Diseases

Prophylaxis of the Common Cold. Theodore Walsh, M.D.
Significance of Calcified Nodules in the Lungs and Tracheobronchial Lymph Nodes. Robert Moore, M.D.
Clinical Aspects and Localization of Bronchiectasis. Daniel W. Myers, M.D.
Lung Abscess: Localization and Surgical Management. Brian Blades, M.D.
Bronchiogenic Carcinoma. Evarts A. Graham, M.D.
Clinical Considerations in the Diagnosis and Treatment of Pleural Effusions. H. I. Spector, M.D.
Pathology of Atypical Pneumonia. H. Pinkerton, M.D.

Newer Additions to Radiation Therapy

Protracted Radiation. Frank H. Ewerhardt, M.D.
The Cyclotron: Its Medical and Biological Application. R. L. Thornton, Ph.D.
The Electron Microscope: Its Principles and Applications. Gordon Scott, M.D.
Transition of Polycythemia to Myeloid Leukemia. G. O. Broun, M.D., and F. N. Zarlengo, M.D.
Therapy of Leukemoid States and Subacute Leukemias. Carl Moore, M.D.

Saturday, A.M., February 14, 1942
Research in Dermatology

Pemphigus. Walter Herold, M.D.
Magnesium Deficiency in Neurodermatosis. Ross MacCardle, M.D.
Radiation Effect on Fungi. Morris Moore, M.D.

Radiation Treatment of Blastomycosis Cutis. A. H. Conrad, Sr., M.D.
Early Skin Cancer Therapy Problems. M. F. Engman, Jr.
Contraindications to Radiation Therapy in Certain Dermatological Conditions. Richard S. Weiss, M.D.

Research in Cancer

The Course of Cancer Research. E. V. Cowdry, M.D.
Clinical Aspects of Cancer Therapy. M. G. Seelig, M.D.
Histogenesis of Skin Cancer. William Cramer, M.D.
Mitotic Rhythm and Radiation. Zola Cooper, M.D.
Photometric Determination of Microchemical Reactions. Robert Stowell.
Ultracentrifugation of Cancer Cells: Viscosity of Cancer Cells. Francis Paletta, M.D.
Clinical and Physiological Study of Isolated Epidermis. Valentina Suntzeff, M.D., J. P. Baumberger, M.D., and E. V. Cowdry, M.D.

Saturday, P.M., February 14, 1942
Digestive Tract

Hyposthemia. Ralph Kinsella, M.D.
Diverticulitis of the Small Bowel. John J. Hershey, M.D.
The Bile Factor in the Production of Cholecystitis. Nathan A. Womack, M.D.
Significance of Suppression as Seen in Intravenous Urography. Cyrus E. Burford, M.D.

Head and Neck

Diagnosis of Atlanto-occipital and Cervical Spine Lesions. Frederick A. Jostes, M.D.
Serious Systemic and Local Complications of Ethmoid Sinus Disease: Value of Laminagraphy in this Diagnosis. Alfred J. Cone, M.D.
Neuralgia. L. R. Main, D.D.S.
Infections and Fractures of the Mandible. J. Barrett Brown, M.D.
Don't Take Your Word For It. J. V. Cook, M.D.

AIR RAID PRECAUTIONS FOR USERS OF RADIUM

In the department of Foreign Letters of the *Journal of the American Medical Association* for January 31, 1942, page 396, appears a summary of the Air Raid Precautions to be Taken by Holders and Users of Radium issued by the Ministry of Home Security of London. These instructions seem important and the summary is reprinted here.

The minister of home security, in consultation with the Ministry of Health, has had under consideration the question of the safe custody, handling and transport of radium under war conditions. In addition to the radium held by hospitals under arrangements with the Radium Commission and King Edward's Hospital Fund for London, an appreciable amount is in the hands of small hospitals, physicians and commercial firms. The minister has decided that for the protection of the public it is necessary to bring to the notice of all who have the custody of radium the precautions which should be taken to avoid its dispersal by enemy action and the course to be followed in the event of its dispersal.

All radium exceeding 1 mg. in amount, not in actual use, should be kept in a bore hole or steel container of approved type. The bore hole should have a depth of about 50 feet, depending on the nature of the subsoil. It should be lined with steel tubing and have a diameter of 6, 8 or 10 inches, depending on the amount of radium to be stored. The bottom of the shaft should be cemented. At the ground level there should be a superstructure consisting of a concrete enclosure with a door fitted with winch and cable to raise or lower the radium receptable.

The approved type of steel container consists of a block of mild steel, either round or square in section, with a central cavity and a screwed plug to seal this. The receptacle is protected by a layer of resilient material, such as cork or rubber, which is within the cavity. The wall thickness of the steel block must not be less than 3 inches. Not more than 350 mg. of radium should be kept in one steel container. In a hospital situated in a vulnerable area, not more than this amount should be in use at any one time. Radon should be used instead of radium when this is possible without loss of therapeutic efficiency. Patients should not remain under treatment by radium during an air raid unless in a basement or ground floor room strengthened up to the approved standard for an air raid shelter.

Radium should not be transported through the medium of the post office. It should be sent either by a special messenger or by a passenger train, in which case it should be handed to the

guard and taken over from him at the station of destination. If less than 10 mg. is so conveyed, it should be enclosed in a container lined with 3 mm. of lead. For 10 to 50 mg. the container should be supported in the center of a box of a minimum of 1 foot in every dimension.

In the event of dispersal of radium—actual or suspected—the occurrence should be notified to the health officer, who will arrange for the danger area to be cordoned off immediately after fire and casualties, if any, have been dealt with. The occurrence should then be notified to the minister of health, who will arrange for experts to examine the site and advise as to further action.

STRUCTURAL DEFORMITIES OF THE SPINE FOLLOWING BILATERAL LAMINECTOMY*

Addendum: Case 11 has recently returned for examination after an absence of almost one year. She complained of severe backache, and this time the neurological findings indicated the presence of an intraspinal lesion. This was supported by spinal fluid studies and a lipiodol myelogram, and was substantiated on February 19, 1942, when the site of her previous laminectomy was explored and disclosed a neurofibroma (recurrence?) involving the second and third lumbar nerve roots.

In retrospect, it is not unlikely that this intraspinal lesion was present at the time of the original report, even though the neurological studies were negative, and that it may have been responsible for her back symptoms at that time. The importance of the spinal deformity with which the report concerns itself specifically is not lessened thereby, and there is reason to believe that it has been partly responsible for her backache.

Thomas Horwitz

* Am. J. Roentgenol. & Rad. Therapy, Dec., 1941, *46*, 836–840.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

Diverticula and Diverticulitis of the Intestine: Their Pathology, Diagnosis, and Treatment. By Harold C. Edwards, M.S. (Lond.), F.R.C.S. (Eng.), Surgeon and Lecturer in Surgery to King's College Hospital, London; Surgeon to the Evelina Hospital for Sick Children, London; etc. With Foreword by Gordon Gordon-Taylor, O.B.E., M.S., F.R.C.S. Cloth. Price, $8.00. Pp. 335, with 223 illustrations, many in color. Baltimore: Williams & Wilkins Company, 1939.

In 1932 the Jacksonian Prize of the Royal College of Surgeons was awarded to Harold C. Edwards, M.S. (Lond.) F.R.C.S. (Eng.) for his essay on "Diverticula of the Large and Small Intestine." The present book is this essay, revised and brought up to date. The clinical data were obtained from case histories of patients suffering from symptoms due to the presence of diverticula or in whom diverticula were found at operation or postmortem or were revealed during a roentgen examination. The majority of the cases were examined personally by the author. In addition, a questionnaire was sent to all patients in whom diverticula were found on roentgen examination. The roentgen material was derived mainly from King's College Hospital during the period 1925–1937 inclusive.

The book is divided into four sections. The first deals with congenital diverticula, the second with diverticula of the duodenum, the third with diverticula of the jejunum and the fourth with those of the large intestine. In each section with the exception of the first, the incidence, morbid anatomy, roentgenological aspect, pathogenesis, etiology, clinical aspects and complications are discussed. Diverticulitis is fully covered. In the discussion of the surgical treatment, operative technique as well as indications for operation and early and late results is included. There is a wealth of information in this volume which is presented in a logical and comprehensive fashion indicative of careful and painstaking study and correlation of records. The bibliography at the end of the volume is complete.

The roentgenologist will find some technical procedures described which are little used in this country. For instance the use of dual exposures is suggested to aid in the differential diagnosis of defects caused by cancer or by diverticulitis. Again, colloidal thorium oxide is to be preferred to barium when the double contrast method of examination is employed inasmuch as the latter tends to fragment. A preliminary enema of sodium phosphate is used to obtain a high pH of the interior of the colon. A low pH produces a granular deposit of barium on insufflation of the large bowel whereas a high pH produces an elastic deposit which delineates the mucosa in better fashion. An hour after the sodium phosphate enema is given, the enema of diagnothorine is injected and films are exposed with bowel fully injected, after evacuation and after air distention.

The subject as Gordon-Taylor states in his Foreword "is one which must appeal to physicians, surgeons, pathologists and radiologists, and within the covers of this book the reader may find all that pertains to the condition."

R. S. Bromer

Tomography. By J. B. McDougall, M.D. (Glasg.), F.R.C.P. (Ed.), F.R.S.E., Fellow of the Royal Faculty of Physicians and Surgeons, Glasgow; Adviser in Respiratory Diseases to the British Legion; Medical Director, Preston Hall, Maidstone, Kent; Medical Superintendent, Douglas House, Bournemouth. Cloth. Price, 21/–. Pp. 73, with 110 illustrations. London: H. K. Lewis & Co., Ltd., 1940.

This book was written to indicate the value of tomography in the diagnosis and treatment of pulmonary tuberculosis. For the most part, it is composed of a series of well-captioned tomograms showing the various manifestations of pulmonary tuberculosis, both before and during treatment, but included are some illustrations, principally of bronchogenic carcinoma, from the collection of the late Dr. E. W. Twining. The superiority of the body section method for visualization of tuberculous cavities is emphasized by contrasting the ordinary and tomo-

graphic roentgenograms of each patient. The author stresses its value to reveal residual tuberculous cavities thought to be collapsed by thoracoplasty as judged by previous conventional roentgen studies. The book is not intended as a complete exposition of the subject but a discussion of the geometric principles of tomography, and a good bibliography, along with an ample number of excellent illustrations, makes it a worthwhile addition to the library of anyone interested in body section roentgenography as applied to pulmonary tuberculosis.

BARTON R. YOUNG

DIE ENTZÜNDUNGSBESTRAHLUNG. Von Dr. med. habil. R. Glauner, Dozent für Röntgenologie an der Universität Köln, Oberarzt am Röntgen- und Lichtinstitut Bürgerhospital. Cardboard. Price, RM. 15.00. Pp. 190, with 14 illustrations. Leipzig: Georg Thieme, 1940.

It is evident that radiotherapy for inflammatory conditions is receiving more and more attention on the part of radiologists, as well as on the part of other physicians. During the past year at least two books on the subject have appeared in German. This one by Dr. Glauner, Dozent in Roentgenology at the University of Köln, is one of these two books. It represents a short but satisfactory summary of the subject. The book is divided into two main parts, one dealing with general considerations and the second part dealing with the treatment of inflammatory lesions as they affect different structures in the body, beginning with the skin and going inwards. Those who can read German easily will find this book well worth their attention. The bibliography included at the end of the book covers most of the work done in this field. This bibliography has been abbreviated to the maximum degree by leaving out titles and frequently leaving out the year of publication.

A. U. DESJARDINS

BOOKS RECEIVED

ORBITAL TUMORS: RESULTS FOLLOWING THE TRANSCRANIAL OPERATIVE ATTACK. By Walter E. Dandy, Adjunct Professor, Neurological Surgery, Johns Hopkins University. Cloth. Price, $5.00. Pp. 224, with 100 illustrations. New York: Oskar Piest, 1941.

DISPLACEMENT OF THE CALCIFIED PINEAL BODY IN ROENTGEN PICTURES AS AN AID IN DIAGNOSING INTRACRANIAL TUMOURS. An Anthropometrical-Statistical Analysis. By Bengt Lilja. (*Acta radiol.*, Suppl. XXXVII.) Paper. Price, Sw. Cr. 10.00. Pp. 183, with numerous diagrams and tables. Stockholm: P. A. Norstedt & Söner, 1939.

SURGICAL DISEASES OF THE SPINAL CORD, MEMBRANES, AND NERVE ROOTS: SYMPTOMS, DIAGNOSIS, AND TREATMENT. By Charles A. Elsberg, M.D., Emeritus Professor of Neurological Surgery, College of Physicians and Surgeons, Columbia University; Emeritus Director of Neurosurgery, Neurological Institute of New York; Consulting Surgeon, Mount Sinai Hospital, New York. With Chapters by Cornelius G. Dyke, M.D., Associate Professor of Radiology, College of Physicians and Surgeons, Columbia University; Director of the Department of Roentgenology, Neurological Institute of New York, New York City, and Abner Wolf, M.D. Assistant Professor of Neuropathology, College of Physicans and Surgeons, Columbia University; Attending Pathologist, Neurological Institute of New York, New York City. Cloth. Price, $14.00. Pp. 598, with 249 illustrations. New York: Paul B. Hoeber, Inc., 1941.

THE STORY OF CLINICAL PULMONARY TUBERCULOSIS. By Lawrason Brown, M.D., Late Director of Trudeau Sanatorium; Lecturer in Trudeau School of Tuberculosis; Author of "Rules of Recovery from Tuberculosis," etc. Cloth. Price, $2.75. Pp. 411. Baltimore: Williams & Wilkins Company, 1941.

TUMORES PRIMITIVOS MALIGNOS BRONCO-PULMONARES: CANCER, SARCOMA, LINFOGRANULOMA. By Julio Palacio, Profesor Adj. de Clinica Medica de la Fac. de Med. de Bs. Aires; Director del Dispensario Municipal de Vias Resp. No. 2, and Egidio S. Mazzei, Prof. Adj. de Clinica Medica de la Fac. de Med. de la Plata; Jefe de Clinica de la Catedra del Prof. Castex, etc. Paper. Pp. 401, with 129 illustrations. Buenos Aires: El Ateneo, 1940.

THE MODERN TREATMENT OF SYPHILIS. Second edition. By Joseph Earle Moore, M.D., Associate Professor of Medicine, The Johns Hopkins University; Physician-in-Charge Syphilis Division of the Medical Clinic and Visiting Physician, The Johns Hopkins Hospital, Baltimore; Special Consultant, United States Public Health Service. With the Collaboration of Jarold E. Kemp, M.D., Associate in Venereal Diseases, Johns Hopkins

University; Harry Eagle, M.D., Passed Assistant Surgeon, United States Public Health Service and Lecturer in Medicine, Johns Hopkins University; Paul Padget, M.D., Associate in Medicine, Johns Hopkins University; and Mary Stewart Goodwin, M.D., Instructor in Pediatrics, Johns Hopkins University. Cloth. Price, $7.00. Pp. 674, with 92 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

Rheumatic Fever. Studies of the Epidemiology, Manifestations, Diagnosis, and Treatment of the Disease during the First Three Decades. By May G. Wilson, M.D., The New York Hospital and Department of Pediatrics, Cornell University Medical College, New York City. Cloth. Price, $4.50. Pp. 595, with 47 illustrations and 79 figures. The Commonwealth Fund; London: Oxford University Press, 1940.

Wounds and Fractures: A Clinical Guide to Civil and Military Practice. By H. Winnett Orr, M.D., F.A.C.S., Lincoln, Nebraska, Chief Surgeon, Nebraska Orthopedic Hospital; Fellow of the American College of Surgeons, etc. Cloth. Price, $5.00. Pp. 227, with 137 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

A Manual of the Treatment of Fractures. By John A. Caldwell, M.D., Professor of Professor of Clinical Surgery, College of Medicine, University of Cincinnati; Director of the Fracture Service, Cincinnati General Hospital, Cincinnati. Cloth. Price, $3.50. Pp. 150, with 76 illustrations. Springfield, Illinois: Charles C Thomas, 1941.

Malignant Disease and its Treatment by Radium. By Stanford Cade, F.R.C.S., Surgeon, Westminster Hospital, Mount Vernon Hospital, and The Radium Institute; Lecturer in Surgery, Westminster Hospital Medical School; Associate Examiner in Surgery, University of London, etc. Cloth. Price, $18.00. Pp. 1280, with 623 illustrations, many in color. Baltimore: Williams & Wilkins Co., 1940.

King Gustaf V's Stockholm Jubilee Clinic for Radiotherapy and Research in Cancer: A Description. (*Acta radiol.*, Suppl. xxxviii.) By Gösta Forssell, Elis Berven, Olle Reuterwall and Rolf Sievert. Paper. Price, Sw. Cr. 8.00. Pp. 80, with 8 plans and 32 photographs. Stockholm; P. A. Norstedt & Söner, 1939.

Nueva Doctrina de la Cancerización. Concepto del freno mesodermico postulados y experimentos. Trabajo leído en la Academia de Medicina en la Sesión del día veintisiete de junio de mil novecientos cuarenta. Por los doctores Rafael y Pedro González Rincones. Paper. Pp. 25, with 4 illustrations. Caracas: Tipografia Americana, 1940.

The Biologic Fundamentals of Radiation Therapy: A Textbook. By Friedrich Ellinger, M.D., Research Fellow, Radiotherapy Department, Montefiore Hospital, New York City. Formerly Privatdozent in Radiology at the University of Berlin. With a Preface by Maurice Lenz, M.D., Associate Clinical Professor of Radiology, Columbia University, Director of City Cancer Hospital, Chief of Radiotherapy Departments Presbyterian Hospital and Montefiore Hospital, New York City. English translation by Reuben Gross, M.D., Formerly Resident Physician, Radiotherapy Department, Montefiore Hospital, New York City, 1st Lieut. M.C., U.S.A. Cloth. Price, $5.00. Pp. 360, with 79 illustrations. New York: Elsevier Publishing Co., Inc., 1941.

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DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 105 Rutledge Ave.
Charleston, S. C.

ROENTGEN KYMOGRAPHY IN THE DEMONSTRATION OF CALCIFIED VALVES OF THE HEART*

By LEO G. RIGLER, M.D.
MINNEAPOLIS, MINNESOTA

THE roentgenologic demonstration of calcification of the aortic or mitral valves is the most certain method of making this diagnosis during life. The technique of the procedure and its diagnostic signs have already been thoroughly explored. It is uniformly agreed that calcification of the valves can best be demonstrated by roentgenoscopy, largely because the characteristic motion of the dense shadow produced by the calcification helps to identify unequivocally the intracardiac origin of the lesion. While an area of calcification can be demonstrated in ordinary roentgenograms, when particularly good technique is exercised, it is difficult to demonstrate in this way the intracardiac origin of such calcification.

By means of the roentgen kymogram reasonably good reproduction of roentgenoscopic images may be obtained, motion being reproduced most effectively in this manner. While it seems highly probable that roentgen kymography has been used by others to demonstrate the motion of calcified valves, I was able to find only one reference to this specific use in the literature. Wolferth and Margolies[1] used this

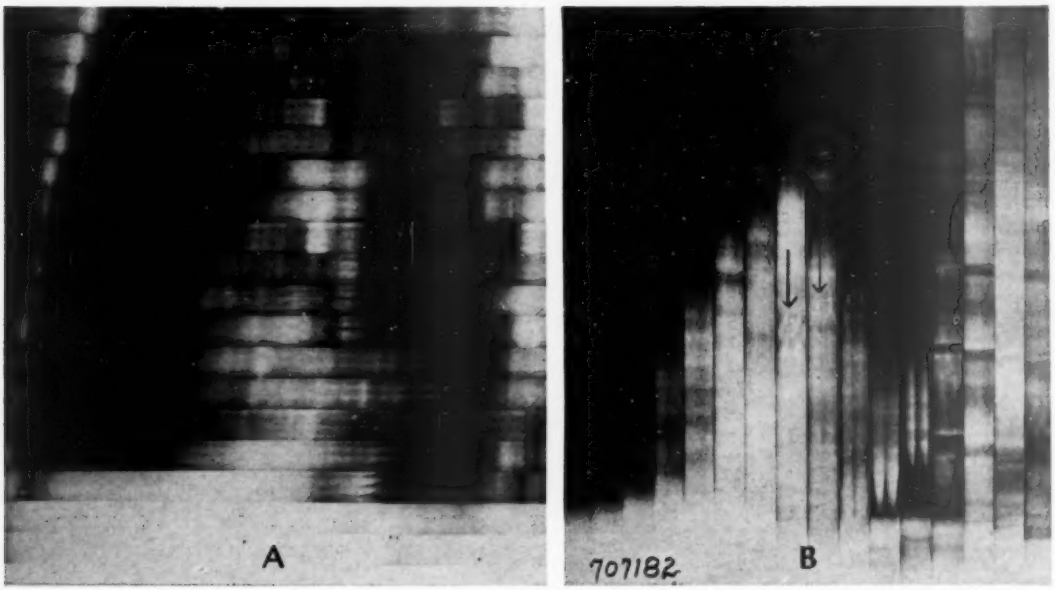

FIG. 1. *A*, roentgen kymogram, horizontal grid, left oblique position in a case of calcification of aortic valves. Note demonstration of horizontal motion of valve (arrows). *B*, roentgen kymogram in same position but with grid vertical. Note the vertical motion of the calcified valve (arrows).

* From the Department of Radiology and Physical Therapy of the University of Minnesota, Minneapolis, Minnesota.

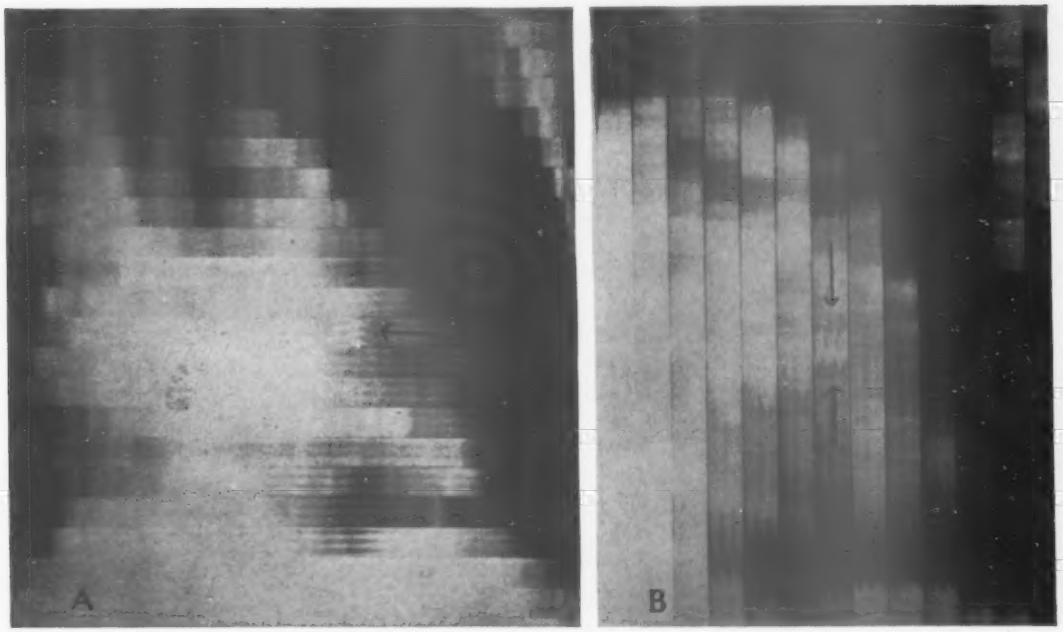

FIG. 2. *A*, roentgen kymogram, horizontal grid, right oblique position in a case of calcification of mitral valve. Note how well the horizontal motion of the valve is demonstrated (arrow). *B*, roentgen kymogram same position but with vertical grid. Note cephalocaudad motion of valve (arrows).

method to study the timing of the cephalocaudad motion of a calcified valve in relation to the heart sounds and to the contraction of the apex of the heart. It would appear to be a splendid method for the clear demonstration of the intracardiac origin of any calcification.

With this in mind, roentgen kymograms were made in 4 cases with obviously calcified cardiac valves. These had been observed previously by roentgenoscopy and had been demonstrated in the ordinary roentgenogram as an area of calcification in the immediate neighborhood of the aortic or mitral valve. Two of these are illustrated here to indicate the value of the procedure.

The first case demonstrates calcified aortic stenosis, undoubtedly of rheumatic origin, in a man aged forty-six. A postero-anterior roentgen kymogram of the heart in the left oblique position with the grid running horizontal to the long axis of the body is illustrated in Figure 1*A*. The motion of the periphery of the heart can be clearly made out, and within the center (arrows) can be seen an area of density showing definite motion horizontal to the long axis of the body. It is notable that none of the other structures in this region shows motion of this character. Careful study of the shadows will reveal the synchronization of the peaks and valleys on both sides of the density indicating that this is simply a to and fro motion rather than an actual expansion. This, obviously, is characteristic of what would be found in a calcified valve. Re-examination was made with the patient in the same position, but with the kymogram placed with the grid running vertical to the long axis of the body (Fig. 1*B*). In this film the cephalocaudad motion of the valve is visible.

In the second case illustrated (Fig. 2) there was found a calcified, rheumatic mitral stenosis in a man aged twenty-one. Here again the characteristic motion of the calcified mass was observed roentgeno-

[1] Wolferth, C. C., and Margolies, A. Movements of roentgen-opaque deposits in heart-valve areas; their relation to heart sounds and auricular filling. *Tr. Ass. Am. Physicians*, 1937, *52*, 346–354. Also, Movements of roentgen-opaque deposits in heart-valve areas; excursions of apex and base of left ventricle compared with that of the left border. *Am. J. M. Sc.*, 1939, *197*, 197–201.

scopically and the calcification itself readily demonstrated in a roentgenogram. A posteroanterior roentgen kymogram in the right oblique position was made with the grid lines running horizontal to the long axis of the body (Fig. 2*A*). This shows, as above, the horizontal motion of the density (arrows). In Figure 2*B* is shown the roentgen kymogram with the patient in the same position, but with the grid placed vertical to the long axis of the body and the cephalocaudad motion of the mitral valve is well demonstrated.

On roentgenoscopic study it can be seen that the motion of the valves is somewhat circular in fashion; by means of these films the cephalocaudad and mediolateral components of this motion are exhibited. Other exposures might well be made at various angles of incidence between the grid and the long axis of the body to demonstrate the character of the movement of these valves. It should be noted that heavier exposures than would ordinarily be used for a simple roentgen kymogram of the heart are advisable in order to bring out the contrast between the calcified valves and the remainder of the heart. Obviously, the great rapidity of exposure which is so necessary in the usual roentgenographic demonstration of calcified valves is not needed when roentgen kymography is used.

Roentgen kymography has been used in several patients in whom there were observed shadows of calcification of lymph nodes superimposed upon the heart, but in no instance did these give any such changes as noted above.

As a method for the study and practical demonstration of the motion of calcified valves of the heart or of any intracardiac radiopaque foreign body, this procedure has considerable value.

Vol. 47, No. 3

AN INEXPENSIVE ROENTGEN TUBE FILAMENT SELECTOR SWITCH

By RUSSELL F. COWING

From the Department of Roentgenology, New England Deaconess Hospital

BOSTON, MASSACHUSETTS

THE control panel of most modern shockproof roentgen-ray generators includes a filament selector switch which permits the operator to choose either one of several tubes, or either of two focal spots on the same tube. It was recently our desire to install a shockproof, double focus, rotating anode tube on a generating unit which was several years old and which did not include a filament selector switch. Such a switch has been built in our shop at a total cost of approximately twenty-five dollars and has been operating satisfactorily for a period of months.

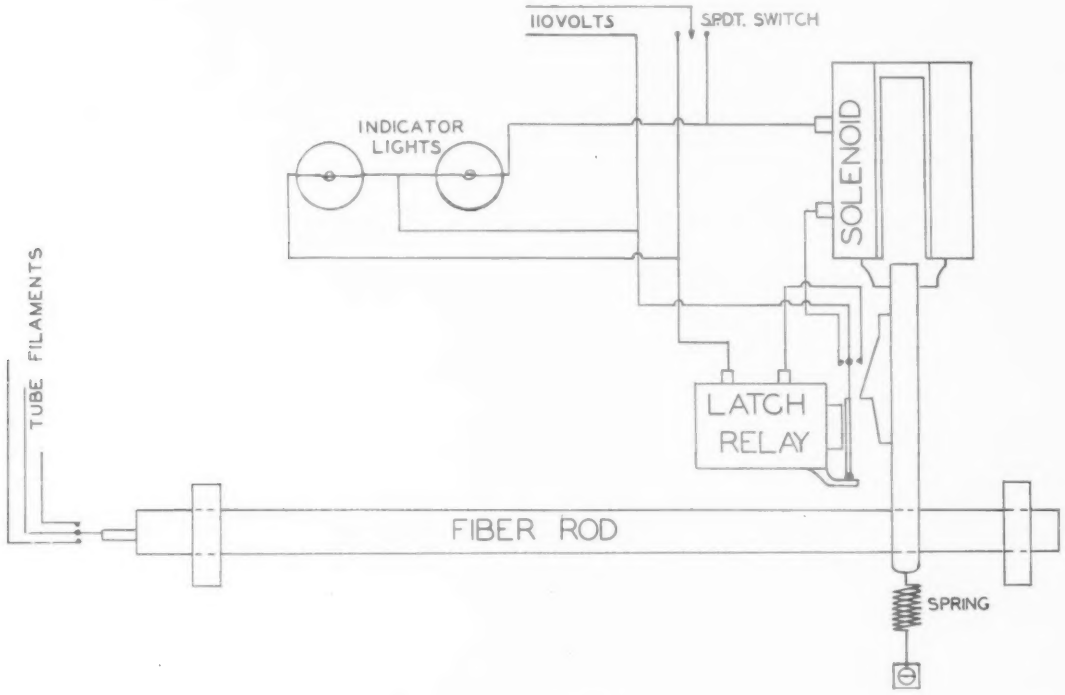

FIG. 1. Schematic Diagram.

The switch consists of a 12 inch fiber rod, $\frac{1}{2}$ inch in diameter, which turns in fiber blocks that act as bearings. The blocks, $4 \times 1\frac{1}{2} \times \frac{3}{8}$ inch are fastened to a wooden base. A solenoid having a pull of one pound is connected to a cam on the fiber rod by a link long enough to allow a "latch" relay to be placed between the solenoids and the rod. When the plunger of the solenoid is energized, the clapper of the "latch" relay engages in a step on the link which connects the solenoid to the fiber rod, thus holding the filament contacts closed after the current has been turned off on the solenoid. When the "latch" relay is energized, the clapper is attracted to the magnet and disengaged from the step. A spring that is attached to the cam on the fiber rod causes the filament selector contacts to change from the small to large focal spot, or vice versa.

We have found that by turning the fiber

rod through 30 degrees a pin located in the end of the rod will shift the filament contacts. The contacts for the filament circuits are mounted on the wooden base and a pin in the end of the rod on the circumference is engaged in a loop on the middle contact of the filament selector contacts that are farthest from the relay or solenoid. The relay, converted into a "latch" relay after purchase, has two sets of single pole, double throw contacts. As only one of these sets is needed to operate the solenoid and latch system the other set is removed and used for the filament circuit.

The distance from the filament circuit to the nearest low potential, or ground, will depend on the highest voltage used on the roentgen tube. A small control panel consisting of a single pole, double throw toggle switch used in energizing the relay or solenoid and two panel mounted lamps to indicate the small or large focal spot can be mounted in the roentgen-ray control booth.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Leszler, Anton. Beiträge zur Röntgendiagnostik der Hyperostosen des Schädels. (Roentgen diagnosis of hyperostosis of the skull.) *Fortschr. a. d. Geb. a. Röntgenstrahlen*, Dec., 1940, *62*, 389–394.

Hyperostoses of the skull are described as compensating, hormonal, dysostotic, or irritative. According to the law of Jores a growing bone subjected to pressure will atrophy while one free of pressure will hypertrophy. This is applicable in the effect of the growth of the brain on the cranial vault. In the first year of life the skull grows primarily by bone formation in the outer table and bone absorption of the inner table. Between the second and twentieth years growth takes place largely at the sutures. After the sixth decade the process of the first year is reversed and there is new bone formation on the inner table as a result of brain atrophy and a slow absorption of the outer table. This senile hyperostosis is the most common and characteristic form of the compensating type. While these changes are generalized in the cranial vault, local changes of the same character may occur as the result of any process leading to a partial or total atrophy of the brain. According to Askanazy the osteosclerosis associated with osteosclerotic anemia is also of this type. The author reports 2 such cases, one of which was confirmed at autopsy.

A characteristic example of hormonal hyperostosis is seen in acromegaly which resembles the transient pregnancy hyperostosis of the cranium. Osteitis fibrosa regarded as a result of overfunctioning parathyroid glands also leads to thickening of the cranial bones. Also in this group belongs the hyperostosis of the internal table of the frontal bone first described by Morgagni in 1767. Stewart, Morel, and Henschen have described the syndrome in more recent years, pointing out the symptoms of obesity, virilism and headache, and the predominance in women. They thought the disturbance lay in the hypophysis or midbrain. Others have thought ovarian dysfunction played a rôle. Moore has studied the syndrome in America and has described four different forms. The author reports 3 cases, all in women; in one there was obesity, in the second headaches and weakness, and in the third a hypophyseal tumor.

Paget's disease (osteitis deformans) and rickets are examples of dysostotic hyperostosis. The changes of the skull in Paget's disease are characteristic and other bones are usually affected also. The cranium may reach 4 cm. in thickness (Kaufmann). The rachitic hyperostosis results from the ossification of osteoid tissue laid down by the periosteum externally.

Irritative hyperostosis may be circumscribed or diffuse. Syphilis, trauma, toxic factors, hematomas, and disturbances in circulation are possible causes.—*W. A. Evans, Jr.*

Dyes, Otto. Angiographie. (Angiography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1941, *63*, 63–84.

Although Egas Moniz in 1932 reported successful results with cerebral angiography in patients, two obstacles have obstructed the general use of the method: (1) the dangers and difficulties of exposing the carotid artery, and (2) the effects of the contrast material. The author recommends the puncture of the carotid artery through the skin under light, general and local

analgesia and the injection of thorotrast. Half the usual amount is used and simultaneous exposures are made with two tubes in anteroposterior and lateral projections. The circulation from the external carotid artery to the jugular vein requires from six seconds to three minutes. With an exposure beginning at the end of the injection and lasting a few seconds, both arterial and venous phases of the cerebral circulation are visualized with the contrast material. At a slightly later period the meningeal and external cranial arteries are visualized. This difference is apparently due to small arteriovenous communications which are normally present. When enlarged they become the so-called arteriovenous aneurysm usually found near the sella turcica. These arteriovenous aneurysms at the base of the skull give an opportunity for blood to return by other channels when the flow in the jugular vein is not sufficient. According to Wolff and Schmid there are three paths: (1) through connections between the sinus cavernosus and the facial veins; (2) through the connection between the sinus cavernosus and the superior sagittal sinus; and (3) through the long unrecognized direct connection of the sinus cavernosus with the sinus rectus. The veins as well as the arteries tend to carry the contrast blood only on one side. More impressive than the basal arteriovenous aneurysms are the peripheral ones which may approach angiomas in character. With large angiomas there may be shrinkage of the adjacent brain substance so that there is no pressure deformity of the ventricles. Sometimes aneurysms are supplied by arteries on both sides so that where an aneurysm is suspected, the injection should be made on both sides. Gliomas and meningiomas may sometimes also be directly demonstrated by angiography. Malignant gliomas have a poorly vascularized center with a rich network of vessels at the periphery. The anterior cerebral artery supplies tumors on or near the midline while tumors situated more laterally are supplied by the middle cerebral artery. Tumors supplied by branches of the external carotid artery are probably meningiomas. A lesion, particularly a subdural hematoma, may be recognized by the displacement of vessels. Löhr has pointed out that the vessels are narrower on the affected side following trauma to the head. Pressure defects on blood vessels have not been observed. Normally there is a marked vascular autonomy on each side of the brain but especially with tumors involving the middle fossa, and also in post traumatic states bilateral filling from a single injection will be observed with the injection either on the diseased or on the opposite side.

A decrease in the normal tortuosity of the vessels giving them a stretched appearance is seen in hydrocephalous and occasionally in the region of tumors, but is not entirely reliable as a diagnostic sign.—*W. A. Evans, Jr.*

Loepp, Willy. Die Retothelsarkome im Schädelbereich. (Retothelial sarcoma in the skull region.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1940, *62*, 211–229.

This type of tumor, otherwise known as reticulo-endothelial sarcoma, was separated from the general group of lymphosarcoma by Roulet in Roessle's institute in 1930 on the basis of a characteristic histologic picture. According to Greifenstein the original site of the primary tumor is in the faucial tonsils in 40 per cent of the cases, in the lymph node areas of the axilla, neck, mediastinum, and groin in 20 per cent, and the rest in the mesopharynx, nasal turbinates, spleen, etc. Rarely the abdominal viscera and skin are involved. Diagnostic of the tumor are argentophile fibrils in the plasma recognized by Foot's staining method. The tumors grow by direct extension and by early metastasis along the lymph channels. They cannot be distinguished on palpation or inspection from lymphogranulomatous, tuberculous, carcinomatous leukemic, luetic, or simple inflammatory lymph nodes. The therapy of choice is irradiation, but the results are not as satisfactory as was first thought and the prognosis on the basis of published statistics is not good. The sphenoid bone and the pyramidal portions of the temporal bone should always be examined for evidence of an extension of the tumor into the base of the skull. Extensions often occur into the cranium and produce intracranial symptoms.

The author reports 8 cases which he has observed in the past three years with numerous roentgen reproductions showing the extent and character of bone destruction. Sometimes the course is very rapid—one boy of eleven died in two and a half months in spite of the application of 5,000 r. Operative procedures, as Eigler and Koch have shown, may lead to a rapid extension of the tumor. Even tumors which are very sensitive to irradiation may lead rapidly to death. The author's results are less favorable then those described in the literature and this he ascribes to the advanced state of the disease

when the patients were first seen. He recommends single doses of 330 r, repeated over a long period according to Holfelder's technique, and the middle cranial fossa together with the whole cervical area should be included in the fields.—*W. A. Evans, Jr.*

Psenner, L. Die Osteomyelitis der Schädelkapsel. (Osteomyelitis of the skull cap.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1941, *63*, 141–154.

Osteomyelitis of the flat skull bones occurs either metastatically as the result of bacterial emboli disseminated from a focus of infection by way of the blood stream or by direct spread from a source of infection, particularly the pneumatic spaces near the skull cap. The first possibility is very rare and has not occurred in the author's large experience, but such cases have been reported following grippe, scarlet fever, angina, typhus, and lung abscess. Infections of the paranasal sinuses, particularly the frontals, most commonly precede the lesions occurring by direct extension. Infected traumatic wounds of the scalp and furuncles of the face may also be the primary lesions, as well as extensions following operations on the ears and paranasal sinuses. The occurrence of osteomyelitis following inflammation of the frontal sinus is attributed to the connections between the veins of the frontal sinus and those of the frontal bone as demonstrated by Zuckerkandl. The rarity of the occurrence of osteomyelitis in association with disease of the middle ear is due to the compact bone which surrounds the mastoid cells and separates them from the medullary areas. The organisms which cause osteomyelitis of the cranial vault are the same as those found in the long bones, i.e., staphylococci, streptococci, pneumococci and typhoid bacilli. Occasionally fungi are responsible. An interval of weeks or months separates the primary infection from the manifestations of osteomyelitis. Complications of the osteomyelitis are meningitis, brain abscess, sinus thrombosis, and orbital abscess. The course of the disease depends in large part on the anatomical character of the bone, whether compact or not, the richness of the diploic venous system and the proximity of the venous sinuses. The course is usually progressive and spontaneous healing is very rare. The disease does not always stop at the suture lines and may cross through small veins, although the connective tissue of the sutures and the denser adjacent bone do offer some obstruction. The disease may be symptomless. If purely exudative in character, it may be present without giving roentgen evidence but eventually small areas of bone destruction are demonstrable and they unite producing larger destructive foci. In cases originating from the frontal sinus the first evidence of bone involvement is an indistinctness of the wall on one side. With a long standing sinusitis there may be a reactive sclerosis of the adjacent bone. Osteomyelitis of the temporal bone occurs almost always after a mastoidectomy and is first made manifest by the indistinctness in the contour of the operative defect. A number of cases are reported with roentgenograms showing osteomyelitic lesions of the skull following infections and operations on the frontal sinus and mastoid areas.—*W. A. Evans, Jr.*

NECK AND CHEST

Stehr, Ludwig. Variationen und Fehlbildungen im Bau des knöchernen Thorax. (Variations and anomalies in the structure of the osseous thorax.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1940, *62*, 1–32; 67–107.

The majority of anatomical variations in the chest involve the number of the ribs. A diminished number represents an advanced step in evolution, while an increased number indicates a regression. This is supported by the fact that in early embryonic life there are more rib anlages than ribs in the adult life (Rosenberg). Variations involve not only the number of the ribs but also their form and development.

The study is based on an examination of 30,000 roentgenograms of the chest. Exceptions may be varied, such as the fact that certain ribs may be entirely or in different proportions cartilaginous and thus not be visible. One may expect 8–10 per cent of the chests to show variations from the "anatomical norm."

The embryology of the spine is reviewed and it is emphasized that the most primitive segmentation into myotomes is not the same as the later segmentation which gives rise to the vertebrae and ribs. A remnant of the primitive segmentation is seen in the zone of rarefaction in the middle of the vertebral bodies where there is a network of blood vessels and also in the inscriptiones tendinea of the rectus abdominis muscle. A vertebral body is formed from the adjacent halves of two primitive segments and also from two cartilaginous nuclei lying lateral to each other so that a body has four

points of origin. The neural arch and dorsal processes develop quite independently of the vertebral bodies so that congenital malformations such as a block vertebra do not necessarily involve the vertebral arch. In embryonic life the myotome segments extend far forward and form two ridges which normally fuse to form the sternum. A failure of closure may affect the bone and also the soft tissues resulting in an ectopia cordis.

Both cranial and caudal displacements of the junction of the cervical-dorsal and dorsal-lumbar segments are recognized. With very rare exceptions the displacement is always in the same direction at the various segmental junctions in the same patient. This was recognized by Adolphi in 1906 and confirmed by Kühne who observed that the direction of the shift was inherited. There is a shortening of the spine which occurs during embryonic life and in the evolutionary development. There is also a tendency toward shortening the thorax in a cranial caudad direction. Gorillas and chimpanzees generally have thirteen pairs of ribs and only four lumbar vertebrae. Small ribs are very frequently observed on the seventh cervical vertebra in childhood and many of these must unite with the transverse processes inasmuch as cervical ribs are much less commonly seen in adults. In examining films of the chest the problem may arise as to whether a small rib at the cervical-dorsal junction is a cervical rib or a rudimentary dorsal rib. Some help may be obtained from the fact that the cervical transverse processes exhibit a definite downward bowing, or are at least horizontal, while the first dorsal transverse processes point upward. The seventh cervical vertebra forms the best landmark for counting the vertebrae, and it may be recognized in the lateral view by the long spinous process which is not bifid as are the other cervical vertebrae. Cervical ribs were encountered fifty times more frequently than a hypoplastic first dorsal rib. The so-called "false" cervical rib articulates with the vertebral body without a recognizable head and neck, while a "true" cervical rib has a capitulum which articulates with a transverse process. No name has been given to the cervical rib which is fused as a synostosis with the transverse process. Usually all of the three forms are without symptoms, but rarely any one of them may give rise to the symptoms of a cervical rib or the scalenus anticus syndrome. The author's classification is as follows: In Group I are the complete cervical ribs possessing a head and neck and resembling closely the thoracic ribs. They occur on the right more often than on the left, but rarely produce a "cervical rib scoliosis." This scoliosis has its convexity on the side with the longer cervical rib. In Group II the cervical ribs articulate in a normal manner but are shorter than those in Group I and anteriorly near the manubrium is a separate triangular ossification center, the ossiculum parasternale. This is not to be confused with the ossiculum suprasternale which is the vestigial remnant of the episternum of lower vertebrates. In Group III there is no ventral portion of the rib and this forms by far the largest group of cervical ribs. The anterior termination may be free or there may be a connection (either osseous or fibrous) with the first rib. The articulation sometimes seen between a cervical rib and the first thoracic rib varies from a few millimeters to 3 centimeters in breadth with the end of the cervical rib forming the head of the joint. The author's observations offer no basis for Freund's theory that tuberculosis is prone to develop on the side where such articulations occur.

A cervical rib may articulate not only with the first dorsal rib but rarely with the scapula or clavicle. Those not having an anterior portion do not pursue a course parallel to the first rib, but more in an oblique direction and the end may be palpable in the supraclavicular fossa. In Group IV are those cervical ribs which are very short and scarcely pass beyond the transverse vertebral process and do not show a recognizable head, neck, and tubercle. These ribs, though small, are important to recognize because they may lead to the same complaints as the large ones. They must be differentiated from separate apophyseal centers for the transverse process of the vertebra which do not produce clinical symptoms. Symptoms may also be produced by the cervical ribs which become fused with the transverse process giving it a raven-beaked shape. Very rarely ribs are seen on the sixth or even the fifth vertebra.

Complete absence of the first thoracic rib is very rare, but dysplasias of all possible varieties occur. The most common variation (0.2–0.3 per cent) is an articulation or synostosis with the second rib. This usually occurs well anteriorly in the region of the anterior axillary line. Sometimes the first rib ends at the articulation, but more often it continues further anteriorly. Such ribs, like cervical ribs, are seen more often in the female. A tumor may be pal-

pable at the site of the articulation with palpable and audible crepitus during movement. An articulation also has been observed between the first rib and the clavicle. A synostosis may vary from a simple bony bridging of the ribs to a complete fusion which is most evident with a block vertebra.

Short first ribs usually tend to a vertical position and lie close to the pleura. With a vertical position of the rib, the corresponding transverse process usually points upward and may form an articulation with the transverse process above. Such articulations may show arthritic changes and be a basis for symptoms. Apophyses on the transverse processes of the first dorsal vertebra which remained ununited after the twenty-second year were observed in 0.1 to 0.2 per cent of the cases. As in other areas, they must be differentiated from fractures. A joint-like formation has been observed in the body of the first rib which the author believes is due to an unrecognized fracture. Such fractures occur as the result of severe coughing and are usually painless and heal poorly.

While variations about the cervical-dorsal junction are varied and deserve special consideration, variations involve the second to twelfth ribs in almost 2 per cent of the cases. The most common anomaly is the forked rib, first described by Luschka. The fourth rib is mostly commonly involved but the fifth almost as often, and the incidence on the right is double that on the left. The least well developed form of the forked rib is the shovel or spatula rib and all intermediate gradations are observed. Such ribs are usually shorter than the adjacent ones. The forking may extend far back to the spinal column and be associated with an anomalous vertebra. As a variation of the forked rib, the author has seen a small accessary rib in the fifth intercostal space anteriorly with a small head which articulated with the fifth rib in the mid-clavicular line.

Among the minus variations, in contrast to the plus variations described above, are bony bridging and joint formation between two ribs. The least developed form of minus variation is an articulation between the tuberosities of adjacent ribs, and there is every intermediate stage to a block vertebra with complete fusion of the ribs. It may be pointed out, however, that a bony bridging of the paravertebral portions of adjacent ribs may not be congenital in nature but acquired, as in Bechterew's disease. In this group also belong the hypoplastic ribs, not uncommon in the first and twelfth ribs and rarely seen in the intermediate ones.

Extreme degrees of malformation are usually found only in children for they are either born dead or die shortly afterwards. Such malformations of the ribs are, as Putti has pointed out, almost always accompanied by malformations of the vertebrae, particularly in the anterior part of the arch where the ribs arise.

The author has observed kymographically that a fractured rib exhibits a much diminished respiratory excursion when compared with its neighbors on the same side. Because of this and the alleged effect of malformations of the ribs on the respiratory mechanics and the development of tuberculosis, the author made kymographic studies and observed a normal respiratory excursion of even markedly malformed ribs.

The malformation of clinical importance is, of course, the cervical rib which produces motor or sensory symptoms by pressure on the adjacent nerves and blood vessels. Although the condition is, of course, congenital, symptoms appear rarely in children and usually at from twenty-five to thirty years of age following some activity placing physical strain on the shoulder girdles. A very large percentage of those with cervical ribs, however, have no such complaint throughout their lives. In the absence of a cervical rib such symptoms may be a part of the scalenus anticus syndrome caused by a shortening, sclerosis, or degeneration of that muscle.—*W. A. Evans, Jr.*

Saupe, E. Erfahrungen beim Vergleich von Schirmbildaufnahmen mit Grossfilmen im Rahmen von Staubarbeiterreihenuntersuchungen. (Experiences in the comparison of fluoro-photographic images and large films in serial studies on those working in dusty trades.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1940, *62*, 145–159.

The author has examined 25,000 workers in the ceramic and mining industries of Saxony and the Sudeten. Twelve cases are reported with illustrations showing the small film increased and the large film reduced to the same size for comparison. The comparison is in general satisfactory. The fluoro-film technique is certainly capable of recognizing a Grade II silicosis, although it may easily be missed in a film of poor technical quality. Occasionally Grade I and even 0-I are recognized or at least suspected. The difficulties and limitations of the

small film technique are described. The films are 24×24 mm. and are examined by projection. The examination of a large series is tiring and it is advisable that two observers be present and that the series be gone through at least twice. Any variations in the "hardness" of the film make it very difficult to recognize silicotic nodules from other pulmonary markings. Variations in the phase of inspiration and in the position of the shoulders are also disturbing. Often one can only make a morphologic diagnosis such as "enlarged hila." Vessels are difficult to distinguish from small areas of calcification.—*W. A. Evans, Jr.*

Gaubatz, Erwin. Die Porphyrsilikose. (Porphyry silicosis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1940, *62*, 395–404.

In the construction of a mountain road eight workers were engaged for nine months in boring porphyry rock containing 74.55 per cent silicate with 50 per cent free quartz. Porphyry has previously been regarded as of little danger. Two of the men were chiefly occupied in removing the rock while the others operated the pneumatic drills and were exposed to a heavy dust laden atmosphere. No water was used in the drilling and masks were not worn. Three of the men died of a severe silicosis and three others are known to be afflicted with moderately severe or severe silicosis. The two workers engaged in the transport of the stone were not affected appreciably. Magnin has reported a similar experience with a larger number of workers in the construction of a tunnel in West Virginia where several hundred of 2,500 workers were severely afflicted with a subacute silicosis after an exposure of seven to seventeen months.—*W. A. Evans, Jr.*

Kommerell, B., and Wedler, H. W. Interstitielles Lungenödem im Röntgenbild. (The roentgen picture of interstitial pulmonary edema.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Oct., 1940, *62*, 258–261.

The observations here reported were on a thirty year old man suffering from acute nephritis. Fourteen days before admission he suffered angina with high fever and tonsillar abscesses. A week later his face and legs became swollen and the urine output was much reduced. Upon a diet of fruit juices the edema disappeared rapidly and the other symptoms were relieved. The roentgen study of the chest made on the first day showed dense clouding in the hilar and perihilar areas with confluent spotty shadows in the right lower medial lung field. The peripheral lung fields were clear and there was a normal caliber of the pulmonary vessels. These findings were present in the absence of râles, cough, cyanosis, dyspnea, and leukocytosis, and at no time was there fever. The lesions cleared rapidly and were interpreted as being due to edema of the interstitial tissues in the hilum. Similar cases have been reported by Zdansky and by Lelong and Bernard, and comparable observations have been made in rabbits by Karasik, Lindenbraten, and Lochow. The authors regard this interstitial edema as a precursor or very early form of the pulmonary edema recognized clinically.—*W. A. Evans, Jr.*

Krohn, Karl-Heinrich, and Baer, Werner. Zur Technik der Bronchographie und zur Diagnose des Bronchialkarzinoms. (The technique of bronchography and the diagnosis of bronchial cancer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1941, *63*, 267–284.

The authors have used the technique of Strnad with the following procedure: Two days before the examination, the patient receives 10 drops of a 1 per cent atropine solution three times daily. One-half hour previously in a fasting condition he receives a morphine-atropine solution intramuscularly and with particularly sensitive individuals 10 to 15 drops of a 1 per cent dicodid solution. The mouth, tongue, and throat are anesthetized with swabs containing a 2 per cent solution of pantocain and the lower air passages with a spray. With the anesthesia complete the Strnad sound, consisting of a thin flexible rubber catheter, is introduced into the trachea. The tip of the sound bears a metal olive to which a fine silk thread is fastened by means of which the tip of sound may be directed when in the bronchial tree. The final positioning of the sound and the injection of the iodized oil are carried out under roentgenoscopic control with "spot" films made in the most advantageous projections.

Problems in the differential diagnosis of bronchial cancer are discussed. Cases have been divided on the basis of the bronchographic picture as follows. Group 1 consists of those lesions with a predominantly endobronchial development with three subgroups: (*a*) polypoid growths into the lumen of larger bronchi, (*b*) lesions with a localized infiltration and thickening of the wall producing a concentric narrow-

ing of the lumen, and (*c*) tumors causing stricture and shrinking of the bronchus with a conical termination of the lumen. In Group II are the lesions with a predominantly extrabronchial extension and they have been divided into (*a*) those tumors which narrow or occlude the bronchus by external pressure—in such instances the main bronchial wall affected by pressure may be quite smooth with the tumor arising from a much smaller bronchus near the hilum—and (*b*) tumors infiltrating and destroying the pulmonary parenchyma to which are also added the effects of edema, exudate, and atelectasis in the alveoli.

A group of cases illustrating the various types of bronchographic manifestation in bronchial carcinoma is presented. Bronchography is indicated where there is the slightest suspicion of bronchial cancer including all infectious processes with atypical infiltrations, effusion or pleural thickening. However, such a study should not be done before careful sputum studies have excluded the possibility of tuberculosis and when the clinical or roentgen appearance indicates a primary inflammatory process. Cachexia and vascular disease are also contraindications.—*W. A. Evans, Jr.*

Eggs, Franz. Beiträge zur Differentialdiagnose rundlich begrenzter Verschattungen im Bereich des Pulmonalbogens. (The differential diagnosis of round circumscribed shadows in the region of the pulmonary arch.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1940, *62*, 188–195.

An abnormal prominence and enlargement of the arch of the pulmonary artery are observed quite often in serial studies of large groups. In a considerable proportion this is a finding without significance. In the differential diagnosis benign and malignant tumors of the left hilum must be excluded as well as pleuritic contractions. This leaves the following three essential factors: (1) congenital anomalies of the heart and great vessels; (2) increased pressure in the lesser circulation, and (3) changes in the walls of the heart and great vessels.

In the first group belong the patent ductus Botalli, unequal division of the truncus arteriosus, congenital narrowing of the pulmonary arteries, and a congenital hypoplasia of the vessel wall. Among the causes of pulmonary hypertension are, first of all, mitral stenosis and rarely septal defects, perforation of an aortic aneurysm into the pulmonary artery, cirrhotic processes in the lung and pulmonary sclerosis. Syphilis is the most frequent cause of an alteration in the vessel walls with tuberculosis, trauma, and senile changes among the rare causative factors.

Four cases illustrating the difficulties in differential diagnosis are reported. The first was a fourteen year old girl complaining of fatigue and with a prominent conus pulmonicus as the only positive finding. In the course of five years the prominence had become less marked and it was concluded that this represented a delayed closure of the ductus Botalli. The next case was a forty-five year old man with increasing dyspnea, hemoptysis, and dizziness. Six years previously cardiac enlargement and enlarged hilar masses led to a diagnosis of neoplasm of the lymph glands. Irradiation brought new improvement. At later studies these shadows were found to have vigorous arterial pulsation and were interpreted as an aneurysmal dilatation of the pulmonary arteries of unknown etiology but possibly on the basis of an auricular septal defect. Case III was a forty year old syphilitic who had been treated for many years. He complained of dyspnea on exertion and palpitation. A sharply outlined mass was seen on the left mediastinal border in the region of the auricle, elevating the left main bronchus, and distinct from the descending aorta. There was a vigorous pulsation synchronous with the aorta. A diagnosis of aneurysm of the left auricle associated with an atypical mitral stenosis was finally made. The last case was a sixty-five year old man complaining of substernal pain. There was a hypertension of 220/115 and the heart was enlarged to the left. Beneath the aortic arch was a round shadow of lesser density than the aorta, which exhibited a lively pulsation synchronous with the aorta. In oblique projections the mass was seen to be an aneurysm of the aorta in the posterior portion of the arch.—*W. A. Evans, Jr.*

Ruffin, Marshall deG., Castleman, Benjamin, and White, Paul D. Arteriosclerotic aneurysms and senile ectasia of the thoracic aorta. *Am. Heart J.*, Oct., 1941, *22*, 458–468.

The authors have examined 9,600 autopsy records at the Massachusetts General Hospital and found 60 syphilitic aneurysms of the thoracic aorta, 3 cases of arteriosclerotic aneurysm, and 3 more of senile ectasia of the thoracic aorta without arteriosclerosis. Of the aneurysms of the abdominal aorta, 3 were

syphilitic and 17 were arteriosclerotic. Until recently it has been assumed that all thoracic aneurysms, with rare exceptions, were syphilitic in origin, but now it is realized that a considerable number are without evidence of syphilis and have developed on a purely arteriosclerotic basis. With the more widespread treatment and better control of syphilis and more prevalent longevity, it is expected that the proportion of arteriosclerotic aneurysms will increase. An aneurysm discovered in the aged, particularly in elderly women, without serologic or other evidence of syphilis is most probably arteriosclerotic in character. Two such cases, occurring in women aged eighty-two and seventy-six, are reported in detail. One died from rupture of the aneurysm into the pleural cavity and the other when the aneurysm became dissecting.—*W. A. Evans, Jr.*

Valet, W. Röntgenkymographische Symptome am Herz- und Gefässbandschatten unter der Einwirkung des manntiefen Stehbades und ihre Beziehungen zur Funktion des Herzbeutels. (Roentgen kymographic symptoms in the heart and great vessel shadows under the influence of a man-deep standing bath and their relation to the function of the pericardium.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1941, 63, 36–46.

The procedure follows in principle Ekert's technique which consists of a deep bath with one wall made of aluminum so that roentgen kymographic studies may be made with the body under hydrostatic pressure. Twenty healthy persons, most of them students, were examined in this manner and all showed an increase in both systolic and diastolic diameters of the cardiac and vascular shadows. In 90 per cent there was a marked decrease of the amplitude of the pulsation on both sides and in 40 per cent there were indeed bilateral cessations of movement usually near the apex. The kymographic pattern of the left border changed in 70 per cent from Type I to Type II according to Stumpf's classification. In all cases there was a tendency to plateau formation at the lateral border of the waves. A double pulsation appeared in 5 per cent and in 30 per cent there was a systolic notching. These changes are all recognized as symptoms of myocardial damage and pericarditis, as well as pneumothorax and pneumopericardium. Inasmuch as the blood pressure remains constant and there is no evidence of cardiac damage, the author believes that the cardiac dilatation which occurs in the bath has a neurogenic basis, probably an increased vagal tone as shown also by the lower pulse rate. In deep inspiration the pericardium limits the cardiac pulsation and in a similar manner the pericardium seems to limit the degree of cardiac expansion in the bath and to flatten the diastolic aspect of the pulsations. The double movement and the notching of the waves are also attributed to the effect of the pericardium.—*W. A. Evans, Jr.*

Dahm, M. Zur Eindellung der Speiseröhre bei links entspringender Arteria subclavia dextra. (The impression on the esophagus caused by a right subclavian artery having its origin on the left side.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, August, 1940, *62*, 108–114.

An examination of the barium-filled esophagus has been shown to be of great value in the study of the mediastinal contents and this has been enhanced by the use of the roentgen kymographic technique. Numerous variations in the origin and branching of the great vessels arising from the aortic arch have been described but these vessels are usually not distinguishable in the upper mediastinal roentgen shadow. Kommerell in a monograph (1936) on variations of the aortic arch first described the roentgen findings in a right subclavian artery arising on the left side and passing behind the esophagus with a normal left-sided aortic arch. In such cases an indentation occurs on the left and posterior border of the esophagus at the level of the aortic arch and is best recognized in the left anterior oblique position. Holzapfel in 1899 reported 200 instances of this anomaly and thought the incidence was about 0.6 per cent. However, in only a few of these was the subclavian artery large enough to affect the esophagus. The large subclavian artery is thought to arise not as usual from the fourth right branchial arch but from the right dorsal aortic root in which case a dilated aortic diverticulum remains. This artery crosses the spine anywhere from the sixth cervical to the fourth dorsal vertebra.

The author's case was a forty-seven year old man who was observed roentgenoscopically in 1938 because of mitral stenosis. There was no dysphagia. The kymographic study showed a marked enlargement of the left auricle on the right side and the esophagus was displaced to the left. These findings were attributed to the mitral stenosis, but in addition there was an

indentation of the esophagus at the level of the aortic arch in the left and posterior wall shown best in the left anterior oblique position. The author feels certain of the lesion present in this case, even in the absence of an autopsy control, although Zdansky has pointed out that lymph nodes may give a similar picture.—*W. A. Evans, Jr.*

ABDOMEN

Berning, Heinrich. Zur Pathologie und Klinik der Hiatusbrüche. (The pathology and clinical findings in hiatus hernia.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1941, *63*, 195–205.

Åkerlund in 1926 first described the roentgen findings when the cardiac portion of the stomach is displaced above the diaphragm through the esophageal opening. Healy and Morrison regarded such a condition as usually due to a congenitally short esophagus and, like the paraesophageal hiatus hernia, more or less as an incidental finding. A third type occurring particularly in the second half of life and involving the distal end of an esophagus of normal length together with the adjacent stomach has provoked much discussion. Berg has described a hiatus insufficiency as a possible predisposition to hernia in elderly pyknics. It is remarkable that these hernias were not found more often at the operative or autopsy table, but this is attributable to their easily reducible character in most cases and to the unfavorable circumstances for demonstration on such occasions. Pathologists using special methods have found senile changes in 75 per cent of individuals sixty to ninety years of age with a bell-shaped formation at the esophageal hiatus which would predispose to a herniation of the third type. These changes are thought to depend upon a senile involution of the left lobe of the liver and of the subdiaphragmatic fat ring with the upward migration of the lower esophagus and cardiac portion of the stomach favored by the positive intra-abdominal pressure and the negative intrathoracic pressure.

Three cases, sixty-nine, seventy-nine, and eighty-two years of age, exhibiting a hiatus hernia type III are reported. These hernias are easily reducible and are much less striking at autopsy than at the roentgen examination because of the postmortem muscular contraction. The various symptoms of such hernias have been grouped by v. Bergmann under the term "epiphrenal syndrome." A fourth to a third of them are without symptoms although the small ones may give signs of esophageal obstruction. The patients usually complain of pain or a sense of pressure in the epigastrium, occasionally leading to vomiting of recently ingested food. Relief may be obtained by walking about or by drinking carbonated waters. Bleeding is common as the result of a congestive gastritis and mucosal erosion. True ulcerations are rare but one of the author's patients died of a bleeding ulcer near the hiatus ring.—*W. A. Evans, Jr.*

Pöschl, Max. Beitrag zur Kenntnis der Magentuberkulose. (The recognition of gastric tuberculosis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1941, *63*, 110–115.

Tuberculosis of the stomach is rare, occurring in 0.4–2.6 per cent of autopsies on tuberculous patients and usually in children. A case is reported concerning a fifty-three year old man who suffered for six weeks with anorexia and sour eructations without hematemesis. There was also cough productive of sputum containing tubercle bacilli. The roentgen examination showed cavernous scirrhotic tuberculosis of both upper lung fields. The canal was narrowed in the central portion of the stomach except in the immediate prepyloric area and did not take part in the peristalsis. The kymogram confirmed the impression of a rigid stenosing gastric wall. At laparotomy the examination gave the impression of a tumor and resection of the Billroth I type was carried out. There was no ulceration of the mucosa, but there was extensive infiltration with lymph and plasma cells in the mucosa and muscularis. Typical tuberculous tubercles were found in the subserosa.

In reviewing other cases it is evident that the roentgen appearance is not characteristic and may simulate carcinoma, linitis plastica, lues, actinomycosis, and leukemia. In this instance, the location of the lesion, the failure to palpate a tumor, the mobility of the involved segment, the lack of nodulation or ulceration, and the association with pulmonary tuberculosis spoke against the diagnosis of carcinoma.

Konjetzny has described four principal forms of gastric tuberculosis: (1) miliary tubercles; (2) large tuberculous foci; (3) tuberculous ulcers; (4) circumscribed tumor formation. The general impression is that infection does not occur from ingested bacilli through an intact mucosa but rather by way of the blood stream

or rarely in the lymph channels.—*W. A. Evans, Jr.*

Bade, Heinz. Hat die Röntgendiagnostik eine Verbesserung der Heilungsergebnisse des Magenkrebses gebracht, und besteht überhaupt diese Möglichkeit? (Has roentgen diagnosis brought an improvement in therapeutic results of gastric cancer and does this possibility exist anyway?) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, August, 1940, *62*, 114–122.

Keutner has recently shown the improvement in diagnosis of gastric cancer by a review of the world literature. The errors were 23.3 per cent before 1918, 17.3 per cent between 1918 and 1927, and only 8.1 per cent in the period from 1928 to 1937. To answer the question contained in the title, the author studied the material at the University Clinic in Kiel (107 patients in the years 1909 to 1929) choosing only patients of forty years of age or less. The duration of symptoms was variable, ranging from a few days to eighteen years. An analysis of the symptoms showed no characteristic picture for gastric cancer except in the advanced stages. Eighteen errors in diagnosis are recorded with a falling percentage of error in recent years. Nevertheless there was no improvement in the operative results of those considered operable. The most common error was for an ulcer to be mistaken for a cancer, and the converse error also occurs. Even large cancers, especially those in the cardia, may be missed and occasionally the primary lesion of a metastasizing cancer may be so small as to escape detection both by roentgen examination and at operation. The author strongly recommends that all apparently benign tumors be submitted to operation, for the recognition of their benign character is uncertain at best.

It is possible that the results in gastric cancer may be improved and for this purpose it is important that everyone with gastric distress be examined early by roentgen ray or gastroscopy in the hands of a competent observer who has the possibility of a cancer always in mind. Negative examinations should be repeated if the complaints continue.—*W. A. Evans, Jr.*

Heeren, J. G. Temporäre Magendilatation bei Ulcus duodeni. (Temporary dilatation of the stomach in duodenal ulcer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1940, *62*, 57–64.

Acute gastric dilatation is seen following operations and severe trauma to the abdomen, also in overloading of the stomach, poisoning (veronal), infectious diseases (influenza, typhoid fever, etc.), and following catheterization of the ureters. The onset is sudden and the patient exhibits signs of intestinal obstruction and later symptoms of peritonitis. The mortality as reported in the literature varies from 73 to 40 per cent. Lesser degrees of dilatation without the severe symptoms have been called gastric paralysis by Katsch, and are seen in acute or chronic overdistention of the stomach, in undernourishment, and states of weakness following infections and operations, often in tabes, and finally there are cases of a reflex character following fright or pain.

The author reports 3 cases observed in the roentgen department at the medical clinic in Würzburg with a temporary enormous enlargement of the stomach occurring in the course of one and a half to two hours after starting a gastrointestinal roentgen series. All of the patients had an ulcer on the posterior wall of the duodenal bulb and 2 showed a marked deformity of the bulb. There was no delay in the emptying of the stomach nor when four times the usual quantity of contrast material was ingested so that a gastric paresis cannot be assumed nor is this at all the picture of an acute gastric dilatation inasmuch as there was no vomiting or other grave symptom.

As an explanation for this phenomenon, the author considers fatigue and relaxation of the gastric musculature following increased work, but this does not seem very plausible and a disturbance in the gastric innervation associated with the ulcer is more likely. The phenomenon occurs only on certain days and is accompanied only by a sense of pressure in the stomach region.—*W. A. Evans, Jr.*

Bücker, J. Die Frühdiagnose des Magenkrebses im Röntgenbild. (The early roentgen diagnosis of gastric cancer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1941, *63*, 1–28.

The three parts of the roentgen examination of the stomach are the study of the barium filled stomach, the observation of the motor function, and the study of the internal relief. Four types of carcinoma are described by Borrmann and Konjetzny: (1) the polypoid mushroom-shaped lesion with rare and late metastases, (2) the dish-shaped ulcerated carcinoma with thick, well circumscribed walls, (3) the flat, ulcerating

carcinoma without a distinct wall or border and this is the most common type, (4) the diffuse carcinoma with thickening and stenosis of the whole gastric wall. According to Konjetzny and Orth carcinoma arises in a previously diseased mucous membrane and these predisposing changes may be recognized in part by the roentgen study. The hypertrophic and atrophic gastritis which accompanies and precedes the malignant lesion may give a macroscopic and roentgen picture very difficult or impossible to distinguish from the neoplasm itself. Repeated examinations over a period of months or years have shown a change from a picture of a plastic gastritis to a typical carcinoma. Gastritis is often situated in the antrum and may lead to a marked narrowing of the gastric lumen in this region either as result of thickening of the musculature and the spastic contraction or from the marked mucosal swelling. Both of these types may simulate neoplasm. Polyposis is easy to recognize in the roentgenogram, but it is often difficult to determine whether the polyps are benign or malignant, and in fact both types may exist together. Polyps are a form of inflammatory mucosal hypertrophy and are subject to malignant degeneration. Three instances are recited and illustrated where there was a long history of peptic ulcer or gastritis and where malignant changes were finally detected by roentgen examination and confirmed at operation or autopsy. Early neoplastic changes can only be recognized by a very careful study of the mucosa according to the technique of H. H. Berg.—*W. A. Evans, Jr.*

Somogyi, Gyula. Röntgendiagnose eines retroperitoneal perforierten Zwölffingerdarmgeschwürs. (The roentgen diagnosis of a duodenal ulcer perforating retroperitoneally.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1941, *63*, 221–225.

Perforations most often occur in ulcers situated on the anterior wall of the stomach or duodenum with the escape of air and secretion into the abdominal cavity. A small perforation may close spontaneously. On two occasions where perforation was diagnosed by demonstrating a quantity of free gas in the abdomen, operation disclosed perforation completely sealed by omentum. Sometimes the first examinations may fail to show gas which is demonstrable a few hours later. If the perforation occurs slowly with attempts at sealing off, the lesion is called a penetrating ulcer. A penetration into a hollow viscus is called a fistula and the recognition of a fistulous tract into the gallbladder, transverse colon, or pleural space is not difficult. Perforation may also occur into solid organs such as the pancreas, liver, or spleen. Perforations from the posterior duodenal wall usually produce a retroperitoneal abscess which tends to dissect downwards. They are often difficult to recognize. A case is reported of a forty-eight year old man with gastric complaints for five years. For three days he had vomited gastric contents without blood, then suddenly felt very ill with a severe pain in the epigastrium. The abdomen was distended and very sensitive. Ulcer perforation and appendicitis were considered. No free abdominal gas could be demonstrated roentgenoscopically, but a very peculiar sickle formation of gas was seen in the right renal area with a fluid level near the upper attachment of the right psoas muscle. A small amount of barium was given and was observed to pass from the duodenum into the cavity with the fluid level. The linear collection of gas circumscribed the right kidney. At operation a lumbar incision disclosed pus and confirmed the roentgen diagnosis of a retroperitoneal abscess. The perforated ulcer was observed at autopsy with a connection with an egg shaped retroperitoneal space between the gallbladder and the right renal pelvis. The abscess had dissected on the left to the spine, down into the pelvis about the bladder and rectum and even into the right half of the scrotum.—*W. A. Evans, Jr.*

Bücker, J. Der Pelotteneffekt am Bulbus duodeni ein Symptom des Pankreaskopfkarzinoms. (A pressure deformity of the duodenal bulb as a sign of cancer of the head of the pancreas.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1941, *63*, 303–306.

The roentgen diagnosis of pancreatic disease has lagged far behind that of other abdominal organs. With a very expanding growth one may expect to observe an effect on adjacent structures, or with an infiltrating lesion there may be invasion of the gastric or duodenal mucosa. The most striking pressure changes are observed with pancreatic cysts which deform the barium-filled stomach and bowel. Changes of such magnitude are seldom seen in cancer, especially if it involves the tail. In tumors of the body the stomach may be fixed by omental in-

filtration and the infiltration may be observed extending into the posterior gastric wall. Similar changes occur earlier in the more fixed duodenum when the pancreatic head is the site of the tumor. The best known sign is the widening of the horse-shoe shaped duodenal loop into the form of a C. With invasion, the descending loop in the region of the papilla is usually involved and recognized by the filling defect and crater formation. The author reports the case of a fifty-three year old patient who had suffered an icterus for four months without pain or colic. At the roentgen examination the stomach appeared normal and the duodenal bulb was large and flaccid. By controlled pressure over the bulb there was demonstrated a large filling defect extending from the base almost to the apex and surrounded by a narrow border. Near the apex of the bulb the mucosa folds coursed in a circular fashion. At autopsy the anatomical findings corresponded closely with the roentgen appearance. The carcinoma had grown toward the duodenal bulb and had reached but not broken through the mucosa. The mucosa over the tumor was edematous and produced the filling defect observed roentgenographically.—*W. A. Evans, Jr.*

STRNAD, F. Die Diagnose und Differentialdiagnose der pathologischen Prozesse am extrabulbären Duodenum. (The diagnosis and differential diagnosis of pathologic processes in the extrabulbar duodenum.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Nov., 1940, *62*, 275–308.

The close proximity of the duodenum to so many important organs makes the diagnosis of lesions difficult, but the variety of changes produced in the duodenum challenges recognition and interpretation. The descending portion of the duodenum is particularly important in this respect, containing as it does the mouths of the hepatic and pancreatic ducts. The anatomy of the duodenum is reviewed with emphasis on the possible variations in its course and the relationship to adjacent organs. While the duodenal bulb belongs anatomically and physiologically to the stomach, the superior horizontal portion of the duodenum first shows the typical small bowel mucosal pattern with ring-like folds. Longitudinal folds are seen in the narrowed portion of peristatic waves. The papilla of Vater can occasionally be seen and even the orifice visualized. The diverticulum of Vater, which occurs rarely as a normal variation, has also been visualized. Usually there is rapid passage of the barium and visualization is difficult, but some help is offered by the stasis in the inferior horizontal portion where the mesenteric artery crosses the duodenum. The to and fro movement often seen in this region may be accentuated by pressure of the palpating finger. The examination is best carried out with patient lying prone.

Space occupying extraduodenal expanding lesions produce a deformity of the barium column which may lead to a complete stenosis. Among such processes are an enlarged liver, usually affecting the upper knee and the superior horizontal portion, the gallbladder which normally may make an impression and with enlargement the deformity may be very marked, the ductus choledochus which normally and when dilated by obstruction at the papilla of Vater may make an impression on the first part of the descending portion, the right kidney particularly a horse-shoe kidney affecting the lower knee of the duodenum, an enlarged pancreas particularly pancreatic cysts which produce a characteristic deformity of the duodenal loop, and finally lymph nodes enlarged by infection and granulomas as well as tuberculous and neoplastic involvement which are apt to produce multiple impressions.

Space occupying intraduodenal expanding lesions produce filling defects recognizable in all projections of the ray. To be considered in the interpretation of such lesions are polypoid tumors, sarcomas, and foreign bodies (especially gallstones). Small islets of pancreatic tissue lying orally to the papilla may appear as warty tumors 1 to 1.5 cm. in diameter. Of particular interest in this group are the lesions near the papilla itself. The author has observed 6 cases of cancer of the papilla in 4 of which the diagnosis was confirmed at operation or autopsy. The problem of differentiation of a stone impacted at the papilla of Vater from a cancer of the papilla is discussed.

Extra- and intraduodenal destructive lesions are considered together. They include primary duodenal carcinoma and sarcoma, carcinomas of the pancreas and gallbladder which invade the duodenal wall by extension, as well as neoplastic infiltrations involving the neighboring lymph nodes. Usually gallbladder lesions affect the greater curvature side of the duodenum and pancreatic lesions the lesser, but this is not con-

stant. In some cases a large ulcerating defect must be differentiated from a diverticulum which by contrast, however, usually has a smooth pliable wall with normal mucosal markings.

Duodenal stenosis may be organic or functional in nature. Many of the conditions described above may lead very early to obstruction. Temporary spastic obstruction may result reflexly from adjacent or distant pathologic processes. Congenital stenosis is seen either as a true atresia or a membranous formation or from extrinsic fetal bands.

Inflammatory changes may be diffuse or circumscribed. Two patients were observed where the changes were confined to the region of the papilla. Such changes are commonly associated with inflammatory lesions in the biliary tract or pancreas. Wolke has reported ulcers in the descending duodenal loop and these may lead to stenosis just as those located in the bulb.

Foreign bodies tend to lodge either in the upper or lower knee of the duodenum and, if they are pointed, perforations may occur in these areas.—*W. A. Evans, Jr.*

Heier, Hans. Zur Autoplastik der Bulbusschleimhaut und ihre Bedeutung für die Ulkusdarstellung. (The autoplasticity of the mucosa of the duodenal bulb and its significance in the demonstration of ulcer.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1941, *63*, 28–36.

Forssell first showed the activity of the mucosa itself in the formation of the mucosal pattern which was previously thought to have a fixed anatomical basis. The motility of the mucosa depends upon the muscularis mucosae and the variable fluid content of the submucosa. Various drugs, particularly nerve poisons, have been observed to affect the muscularis mucosae and the effect of the same drug is different in different parts of the stomach. The mucosa thus does not present a constant pattern, although some autoplastic states have been observed to persist for a quarter of an hour. Some of the patterns may simulate a duodenitis or other pathologic change. Pathologic changes are persistent and are usually accompanied by rigidity. Autoplastic changes in the mucosa may conceal a small ulcer niche. Repeated examinations are the best guard against diagnostic error.—*W. A. Evans, Jr.*

Prévôt, R. Ergebnisse röntgenologischer Dünndarmstudien unter besonderer Berücksichtigung der Morphologie. (Results of roentgen studies of the small bowel with particular consideration of the morphology.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Dec., 1940, *62*, 341–388.

Studies of the mucosal relief have yielded brilliant results in gastroenterology, especially in the examination of the stomach, duodenum and colon. More difficult is the examination of the small bowel where the pattern and motility are so variable. Weltz and others have thought that only a functional study of the small bowel was possible. The author believes such pessimism is not justified. The relief pattern of the small bowel is a summation picture, more so than in the case of the stomach or colon, and is determined by the mucosa, the tonus, the secretion, and the motility. For the study of motility a single oral dose of the barium mixture (250–300 cc.) is recommended. A variety of psychic, endocrine, and other factors may affect the motility. For a study of the anatomy a fractionated meal is preferable with swallows of barium about every five minutes following the initial swallowing of 200 cc. Roentgenoscopic study with the palpating hand should be made of every centimeter from the duodenojejunal junction, although this may be difficult for the loops of ileum which lie deep in the pelvis unless they are elevated by a distended bladder or rectum or by elevating the pelvis. Anatomical study of the terminal ileum should be supplemented by a retrograde filling.

Congenital anomalies are described under disturbances in rotation which may affect not only the colon but also the duodenum and lower small bowel and give rise to errors in interpretation and occasionally to such complications as volvulus and intussusception. The author has observed 6 cases of situs inversus in the past four years.

Extra-enteric processes such as lymphadenopathy and ascites give a characteristic arrangement of the loops of small bowel with a diminution in the sharp Y-shaped angles normally seen. Occasionally the impression of isolated lymph node masses may be seen on the small bowel lumen.

Foreign bodies are seen in the small bowel and the worm, *Ascaris*, is readily demonstrable. Worms appear either as filling defects in the barium column with detail films and optimal

compression or from the barium they ingest when very hungry.

Meckel's diverticulum is found in about 2 per cent of autopsies. It lies 0.5–2 meters from the ileocecal valve in adults and 30–50 cm. in children. The roentgen demonstration in contrast to other diverticula is extraordinarily difficult and the reason for this is not apparent. The most common complication is ileus. Periodic bleeding may occur in the spring and fall months. Acquired diverticula are usually multiple and occur on the lesser curvature side of the bowel, most often in the jejunum. Usually they are small and without significance.

Among the less generally recognized indications for an examination of the small bowel is above all the diagnosis of ileus which may be mechanical or paralytic. Obstructions may be congenital or acquired, the former being less common and usually leading to death in the first few weeks of life. There are intraluminal causes of narrowing, such as scarring resulting from an ulcerating process, foreign bodies and calculi, or the basis for the obstruction may be external, e.g., tumors of neighboring organs, fibrous bands, and hernias. A third group includes the invaginations. Most invaginations occur in infancy and, according to Laurell, are caused by enlarged Peyer's patches in the ileum.

In the investigation of acute ileus it is usually possible to differentiate the large and small bowel, but with high degrees of distention this may be difficult as they approach each other in appearance. A barium enema study may be helpful, but barium by mouth is to be avoided as it may aggravate the obstruction. In intermittent ileus more complete studies may be made with the fractionated barium meal and examination of biliary and urinary tracts may be helpful.

The appearance produced in the small bowel by varying degrees and stages of nonspecific inflammation is described from the edematous swollen state of the mucosa to the rigid fibroulcerous wall. A very common type of enteritis is that which usually follows a gastroenterostomy. The functional disturbance is indicated by the tendency for the barium to collect in isolated depots mixed with mucous secretion and there may be formation of fluid levels in the mid and lower small bowel. The author has recognized no cases of terminal ileitis which have been reported so much in the recent American literature.

Intestinal tuberculosis can be found in 90 per cent of adults dying of pulmonary tuberculosis, usually in the lower ileum with infiltration, caseation, and ulceration of Peyer's patches. Healing may occur with stenosis. The most favorable roentgen demonstration comes from filling of the terminal ileum with the barium enema. The mucosa is irregular corresponding with the granular papillary and polypoid excrescences and the bowel wall is rigid. In the region of the ileocecal valve the changes are more proliferative, giving a tumor-like appearance. Ulcers do not appear as a niche but as an irregular ring-like narrowing of the lumen for 1–5 cm.

The demonstration of tumors, although rare, is one of the most rewarding results of the small bowel examination. Among the benign lesions are not only true tumors like fibromas, myomas, and lipomas, but also inflammatory hyperplasias of the mucosa which take the form of adenomas or polyps. The benign tumors become manifest through bleeding, invagination, or ileus. Carcinoma is the most frequent malignant tumor and localizes most often in the upper jejunum or lower ileum. Stenosis, bleeding, and perforation with fistula formation are the common complications. A few cases of sarcoma involving the small bowel are reported.—*W. A. Evans, Jr.*

GENITOURINARY SYSTEM

AJAMIL, L. F., GARCIA ROMEU, J., MEDINA VEGA, J., and MONTEJO, J. L. The role of perirenal insufflation in urology. *J. Urol.*, Nov., 1940, *44*, 607–617.

The technique employed by the authors consists first in preparation of the patient with cathartics and enemas as for the usual survey films of the abdomen. The patient lies with the affected side uppermost and the needle is introduced 2.5 cm. below the 12th rib at a point 1 cm. outside the transverse apophysis of the 2nd lumbar vertebra. The needle is directed slightly inward and downward so as to graze the transverse apophysis of the 2nd lumbar vertebra, passing through the sacrolumbar muscles until the resistance of the lumbar fascia is felt. It is then introduced another 2 cm. into the perirenal fat bed. If blood is obtained the kidney parenchyma has been entered and the needle must be partially withdrawn. When the needle is connected to the pneumothorax apparatus the manometer should record

respiratory oscillations. Air, oxygen or carbon dioxide may be used as media. Using the pneumothorax apparatus the authors then inject 250–500 cc. of air and apply massage over the lumbar muscles to cause better diffusion. Films are exposed immediately after completion of the injection. The air is absorbed in three to four days.

The main objection to the procedure is the occurrence of fatal air emboli. In their series of 23 injections the authors had 3 accidents. The first case recovered after exhibiting evidence of air emboli with brain symptoms and a transient paraplegia. The second case developed a pneumothorax immediately after the procedure, which was resorbed in a few days. The third case, likewise non-fatal, complained of dyspnea and thoracic compression which forced suspension of the procedure.

Several illustrative films are included in the article. The authors conclude that the procedure has its dangers, should not be undertaken in the presence of suppurative lesions, and where the diagnosis can be made by other means, but feel that it should be used in cases of suspected renal or pararenal tumors when the diagnosis cannot be made by simpler methods. —*R. M. Harvey.*

JAFFE, H. L., MEIGS, J. V., GRAVES, R. C., and KICKHAM, C. J. E. Ureteral and renal complications of carcinoma of the cervix; their classification and management. *Surg., Gynec. & Obst.*, Feb. 1, 1940, *70*, 178–184.

The authors point out the value of complete urological studies as a means of directing treatment of patients with carcinoma of the cervix. They show that prompt attention to the urological complications which result from the patient's disease or from radiation therapy will help both the symptomatic and curative results. They studied 13 patients who showed ureteral obstruction before or during roentgen and radium treatment. They point out that ureteral obstruction, in this group, should be treated by dilatation of the ureter, or where this is impossible, by nephrostomy. Two patients developed ureteral obstruction after completion of treatment for carcinoma of the cervix. These patients had no clinical evidence of residual disease. Both of these patients were treated by prompt ureteral dilatation with recovery. Ten patients showed evidence of ureteral obstruction developing after completion of treatment and with positive evidence of residual disease. Only one of these patients was treated urologically and this patient died of uremia in one year and eight months. Postmortem studies in some of these individuals indicated considerable fibrosis of the lower ureter.

Of the total number of 70 cases followed five years after treatment, 35.7 per cent have proved ureteral obstruction. Those patients who were given prompt urological treatment showed good end-results. Those patients not treated died from uremia.—*G. W. Chamberlin.*

BURHANS, R. A. Perirenal air insufflation: An aid in urological diagnosis. *J. Urol.*, Nov., 1940, *44*, 618–638.

The author lists the following roentgen signs of perinephric abscess: scoliosis with the concavity on the affected side, obliteration of the psoas shadow, presence of a soft tissue mass, pyelographic deformities and perirenal air insufflation. He gives the technique of the insufflation and the roentgen exposures used routinely. In his experience no serious accidents occurred. A list of 10 representative cases are summarized to show the value of the procedure. Several illustrative films are included.

Study of the 10 cases reported shows the value of perirenal air insufflation in confirming the presence or absence of perinephric abscess, in deciding the ease and route of operation in renal tumors, in differentiating renal, splenic and gastrointestinal tumors and in outlining adrenal tumors.— *R. M. Harvey.*

BUCKLEY, T. I. Hematuria associated with dissecting aneurysm of the abdominal aorta. *J. Urol.*, Dec., 1940, *44*, 816–820.

The author adds 2 cases to the more than 300 already reported in the literature. The first patient was admitted for painless hematuria of two weeks' duration which had been preceded by an attack of severe substernal pain radiating into the abdomen and finally centering in the lumbar muscles. Blood tests were negative and a definite hypertension was present with diffuse enlargement of the aorta. Cystoscopic examination revealed bleeding from the left kidney. A urogram showed no evidence of calculus and a pyelogram showed a large filling defect in the left renal pelvis with obliteration of the upper major calyx. These findings led to a suspicion of tumor, but after all bleeding had

ceased the pyelogram was repeated and a normal pelvis and calyces were visualized. The previous deformities had evidently been due to blood clots. The patient died later of a cerebral hemorrhage; autopsy showed a healed dissecting aneurysm which had penetrated the left renal artery as well as many other vessels.

In the second case the pyelogram again showed filling defects in the pelvis due to blood clots and likewise a normal pelvis after all bleeding had stopped. Fluctuating hypertension was present. The diagnosis was confirmed by postmortem.—*R. M. Harvey.*

Stevens, W. E. Benign teratomas (dermoid cysts) of the testicle: a case report. *J. Urol.*, Dec., 1940, *44*, 864–870.

The benign teratoma of the testicle or dermoid cyst is rare and complex in form. The author cites a case in a sixteen months old infant which had been present since the age of three months according to the parents. No estimation of gonadotropic hormone was made. Histologic diagnosis following orchidectomy was dermoid cyst of the testicle with excellent prognosis.

Teratomas of the testicle may contain derivatives of all three geminal layers. The tissue cells of the dermoid cysts have reached adult differentiation. Although Ewing believes malignant changes may occur in these tumors, no such case has ever been reported. Practically we must consider teratomas of the testicle as either benign or malignant. It is commonly agreed that the gonadotropic hormone is not increased in the urine of patients with testicular dermoids. Seminomas without lymphoid stroma show less than 20 R.U. unless metastases occur; seminomas with lymphoid stroma show 100 to 500 R.U.; adenocarcinomas will show from 1,000 to 5,000 R.U., and chorionepitheliomas from 200,000 to 500,000 R.U. The author does not believe in the general statement that 50 R.U. or less in the urine of a man with testicular tumor means benign tumor or seminoma, and 1,000 R.U. means adenocarcinoma.

Dermoids are the rarest testicular tumors. They grow slowly, usually occur in infants, and may show calcification on the roentgenogram. In the differential diagnosis adenoma, chondroma, fibroma, lipoma, myoma, syphilis, tuberculosis, hydrocele, and acute orchitis must be considered.

The treatment is immediate orchidectomy. If histological examination shows a benign tumor postoperative roentgen therapy is not indicated. Recently there has been a trend toward preoperative deep roentgen therapy in testicular tumors. This is followed by orchidectomy and postoperative irradiation. The author does not agree with this procedure in benign teratomas because of missing the diagnosis, necessity for expensive treatment which the disease does not require, and the possibility of injury to the healthy testicle.—*R. M. Harvey.*

SKELETAL SYSTEM

Van Nuys, R. G. Normal bone angles and the roentgen report. *Radiology*, Aug., 1940, *35*, 206–209.

An orthopedist complained to the author that roentgenologists' reports on reduced fractures are frequently indefinite. They read simply "good alignment," "fair alignment," "some angulation," etc. The author discusses methods of making reports that will be more helpful to surgeons. He gives roentgenograms of the angles in normal and fractured ankle, hip, elbow and wrist joints, showing normal and abnormal angulation and methods of measuring them. He says that roentgenologists should remember the common normal angles and report the deviation accurately in degrees. This accuracy will help the surgeon to be more accurate in his work.—*Audrey G. Morgan.*

Ratti, Arduino. Due casi di rare lesioni traumatiche del polso. (Two cases of unusual traumatic lesions of the wrist.) *Radiol. med.*, Oct., 1940, *27*, 779–782.

Luxations of the bones of the wrist are unusual. The author describes 2 cases. The first was in a man of thirty-two who suffered a crushing injury of the right wrist. Roentgenograms showed a palmar and proximal dislocation of the scaphoid with a broad separation between the scaphoid and semilunar bones and a proximal dislocation of the os magnum. There was no change in the distal row of wrist bones.

The second case was in a man of thirty-three who suffered a sudden violent rotation of his wrist. In this case there was a palmar dislocation of the os magnum with subluxation of the semilunar and small comminuted fractures.

These cases are interesting because of their rarity and because they show the necessity for careful roentgen examination in frontal, lateral and oblique projections in injuries of the wrist

which may not show clinical signs of serious lesions.—*Audrey G. Morgan.*

CHARNOCK, D. A. Renal rickets. *J. Urol.*, Dec., 1940, *44*, 850–859.

Renal dwarfism, renal hyperparathyroidism, renal infantilism and renal rickets are all terms that have been used to describe the bone changes resembling late rickets which occur in chronic renal disease in children. The condition is not recognized as a rule until bone deformities develop at about the seventh or eight year. Clinically the child exhibits a dry pigmented skin, short stature, waddling gait, polyuria, polydipsia and nocturia. As the disease progresses signs of renal failure appear. Functional insufficiency of the kidneys is the determining factor in the disease entity rather than any specific renal lesion. The most common skeletal deformity is genu valgum. Rachitic rosaries, bossing of the frontal and parietal bones of the skull and pathological fractures of the metaphyses occur. There is swelling of the epiphyseal ends of the shafts due to metaphyseal hypertrophy. Roentgenograms show marked osteoporosis, moth-eaten and honeycombed metaphyses, widened shafts and thinning of trabeculations.

Urinalysis shows low fixed specific gravity, albumin, and pus, blood or casts according to the nature of the lesion. Functional tests invariably show poor function. The calcium of the blood is reduced and the phosphorus elevated. The blood phosphatase is also elevated. Nitrogen retention is present.

In infantile rickets the bone changes are due to an imbalance or deficiency of calcium and phosphorus in the blood. Defective mineralization of growing bone results. In renal rickets it has been shown that mineral deprivation and lack of vitamin D are not factors. It is known that there is an increased blood phosphorus and increased phosphorus excretion in the intestines in renal insufficiency. The latter results in lowered blood calcium due to formation of insoluble calcium phosphate in the intestines. Thus in cases of reduced renal function a true low calcium rickets may occur. Obviously vitamin therapy will be of no avail since the calcium phosphate in the intestines is fixed.

The above theory explains the rachitic changes but not the dwarfism nor the sexual infantilism. To explain these changes endocrine disturbances must exist. It has been proved that renal damage will lead to hyperplasia of the parathyroids. Albright has suggested that this is due to an attempt of the parathyroids to re-establish normal serum calcium and phosphorus and facilitate the elimination of phosphorus from the blood.

A third theory as to the cause of renal rickets is the presence of a lesion of the pituitary gland. It has been postulated that a lesion in the pituitary might produce urinary tract dilatation through the autonomic nervous system, the cerebral centers of which are supposed to lie near the diencephalon. Such a lesion would most satisfactorily explain the dwarfing and sexual infantilism.

Treatment is of little value. Alkalies are advised to combat the acidosis which is usually present. The use of sodium citrate spares the calcium which is called upon to replace loss of fixed base, which occurs in the acidosis. In cases where definite urinary tract obstruction exists relief of the obstruction may be of value in early cases.—*R. M. Harvey.*

DANIS, P. G., and ROSSEN, J. A. Renal rickets. *J. Pediat.*, Jan., 1941, *18*, 103–116.

Renal dwarfism, renal infantilism and renal rickets are synonymous terms. At least 90 cases have been reported. The exact etiology is unknown. The most generally accepted theory is that of renal retention of phosphates, hyperphosphatemia, associated parathyroid hypertrophy and secondary depletion of bone calcium. Some authors believe that the parathyroid disturbance is primary. The authors report 2 cases, in a brother and sister. The boy, who was the younger of the two, had never received cod-liver oil. Intravenous skiodan revealed no kidney function on three different occasions. The phenolsulphonphthalein test showed 14 per cent normal function. Blood calcium was 8.4 mg. Roentgen examination of the long bones showed healing rickets with irregularity of the diaphyses and many so-called phosphorus lines. The child failed to show improvement over a two year period and died of an acute upper respiratory infection with marked edema of the glottis.

The sister was undersized, had slight beading of the costochondral junctions, marked genu valgum and a prominent forehead. Roentgenograms showed slight haziness of the diaphyses. Slight growth retardation was indicated by the presence of only two centers for the carpal bones although the child was three years old. Five years later the child entered the hospital

in acute tetany with a blood calcium of 6.9 mg. and a blood phosphorus of 5.2. Roentgenograms at that time showed a pathological fracture in the upper third of the fibula with marked diaphyseal irregularity. This child appeared markedly benefited by a high potassium diet. The child also exhibited a high sugar tolerance curve which has been reported in renal rickets.—*R. M. Harvey.*

Guye, Pierre, and Rutishauser, Erwin. Considérations sur l'ostéodystrophie rénale à propos d'une observation nouvelle. (Study of renal osteodystrophy in connection with a new case.) *Presse méd.*, Dec. 17, 1940, *48*, 1035–1038.

Kidney disease sometimes causes a generalized bone disease which is to be classified among the fibrous osteodystrophies. The authors describe a case in a man of forty-two who showed chronic nephritis with progressive uremia, high blood pressure with some attacks of decompensation of the heart, thrombosis of the retinal and cerebral vessels and foci of fibrous ostitis in the left tibia. He died of a terminal uremia.

Autopsy showed polycystic kidneys complicated by malignant nephrocirrhosis. There was hyperplasia of the suprarenals and an old area of softening of the brain. There was generalized renal osteodystrophy. The whole skeleton was affected. Some of the foci were visible to the naked eye and others could be detected only by microscopic examination. There were both destructive and reparative processes in the bone. Histological pictures from various foci are given.

Similar lesions of fibrous ostitis are seen in hyperparathyroidism, Basedow's disease, diabetes and intoxications by metals. The pathogenesis is similar; all these diseases cause acidosis. This causes ionization of calcium which is excreted in excess. To compensate this loss the body borrows from its calcium reserves, resulting in decalcification of the bones.

It is a strange fact however that though the lesions are the same in Recklinghausen's disease and renal osteodystrophy the mineral findings in the blood are exactly opposite; in the former disease there is hypercalcemia and hypophosphoremia, while in the latter there is hypocalcemia and hyperphosphoremia. The authors discuss the causes of this difference which is not very well understood. It is also hard to explain the distribution of the lesions. It may be determined by various local reasons. An ordinary cause which would not affect a normal skeleton often has exaggerated results when the bone is already diseased. This sensitiveness of reaction seems to be important in the physiopathology of bone disease.—*Audrey G. Morgan.*

Gittleman, Isaac F., and Pincus, Joseph B. Rickets associated with dwarfism, glycosuria, ketonuria and albuminuria. *Am. J. Dis. Child.*, Dec., 1940, *60*, 1351–1370.

The authors report a case of rickets associated with dwarfism, glycosuria, ketonuria, lipemia, albuminura and chronic acidosis. Studies of the balance of calcium, phosphorus, sodium, potassium, chloride, magnesium and nitrogen were made. Biological and chemical tests to determine dysfunction of the parathyroids, thyroid, pancreas and pituitary were performed and the pancreas and pituitary were the only glands in which some evidence of dysfunction could be found. Observations on carbohydrate and fat metabolism also were made.

The dysfunction of the pancreas and pituitary manifested itself in a disturbance of carbohydrate and fat metabolism, resulting in chronic ketosis and acidosis, hepatomegaly, glycosuria and dwarfism. The acidosis was probably responsible for the chronic hypophosphatemia and the rachitic changes in the bones. The albuminuria and cylindruria can be explained, Gittleman and Pincus believe, on the basis of changes in the renal epithelium secondary to a primary metabolic disorder.

The paper has numerous illustrations of the roentgenographic skeletal changes.—*R. S. Bromer.*

Tunesi, Antonio, and Scolari, F. Contributo alla conoscenza del morbo di Albers-Schönberg. (Study of Albers-Schönberg's disease.) *Radiol. med.*, Nov., 1940, *27*, 825–842.

This disease was first described by Albers-Schönberg in 1904 and named from the characteristic marble-like density of the bones found in it. In addition to this the bones are fragile and fractures are frequent. In many cases the normal trabeculature of the bones disappears completely and the marrow cavity is greatly reduced or completely filled with dense bone. The bones do not show any deformities or curvatures. Sometimes there is exuberant callus formation in fractures. In some cases in children there are transverse bands of greater density

alternating with ones of lesser density, giving the bone a zebra-like appearance which is very characteristic. In the skull there is generally enlargement of the clinoid processes and often enlargement of the foramens. In children closure of the fontanelles is often delayed.

Clinically the bone changes are accompanied by anemia, which sometimes assumes the pernicious type.

Only about 70 cases have been described in the literature. The author gives a table summarizing 59 of these cases and describes 2 of his own in two sisters ten and fourteen years of age. They presented the typical roentgen picture of the disease. Attention was called to it by a fracture of the femur in the younger child. Neither of them showed anemia and none of the other members of the family were affected. These cases show the tendency of the disease to be familial and a marked enlargement of the thyroid in the older child seems to support the theory of its endocrine origin. Its real cause is not known, but unlike other bone diseases in which there is increased density of bone, it may begin in intrauterine life. When it begins in fetal life or early childhood its course is much more rapid and severe than when it begins in adult life. It may progress slowly for decades in adults but so far as is known its course is always progressive and finally fatal.—*Audrey G. Morgan.*

Benassi, Enrico. Ossicino soprannumerario epitrocleare. (Supernumerary epitrochlear bone.) *Radiol. med.*, Nov., 1940, *27*, 875–876.

No mention of a supernumerary epitrochlear bone is found in any of the treatises on anatomy except that of Köhler who describes 4 cases, one of which he himself observed. Neither is any mention made of such a bone in the textbooks on roentgenology.

The author saw a case in a workman twenty-eight years of age who came for examination three days after a fall on his left elbow. He had some pain over the olecranon with moderate limitation of movement. No pain at the site of the epicondyle or the epitrochlea. The roentgenogram did not show any fracture but did show an oval shadow on the median surface of the epiphysis of the left humerus just beneath the epitrochlea. It was caused by a bone the size of an orange seed, oval in shape with its tip extending upward and laterally. It was a supernumerary epitrochlear bone, as shown by the fact that it had a complete bone structure with a cortex and spongy bone. There was no sign of its having been broken off from the epitrochlea, which was also smooth and regular in outline and showed normal bone structure. The supernumerary bone had evidently developed from an accessory center of ossification in the epitrochlea.—*Audrey G. Morgan.*

Pellini, Maria. Malformazioni congenite scheletriche e viscerali rivelate dalla indagine radiologica. (Congenital malformations of the bones and viscera revealed by roentgen examination.) *Radiol. med.*, Nov., 1940, *27*, 857–861.

A boy four years of age was sent for examination for sequels of poliomyelitis. He was found to have an incurvation of the wall of the thorax in the middle and posterior axillary region on the left side. Roentgen examination showed very complex malformations of the vertebrae and ribs on this side, roentgenograms of which are given. There was complete absence of the 5th and 6th ribs on the left side which led to the indentation of the wall at that site.

In view of these malformations a complete roentgen examination of all the organs was made. This disclosed a hernia of the transverse colon through the diaphragm on the left side, in the left posterior paravertebral region known as Bogdalek's trigone. This is the most frequent site of fetal congenital hernia. In addition to this there was complete absence of the left kidney and ureter.

The value of such examinations is obvious. The child had had no symptoms attributable to disorders of either the digestive or urinary tract. If these examinations had not been made the herniated colon might very well have been mistaken for a pulmonary abscess or a cavity opening into a bronchus in later years if examination had been made for a lung affection. It is needless to emphasize the value of knowing that the child had only one kidney if the necessity for a kidney operation ever arose.—*Audrey G. Morgan.*

Law, John L. Multiple cystic tuberculosis of bones: its roentgen picture and reparative process as seen in serial roentgenograms. *Radiology*, Sept., 1940, *35*, 328–335.

Multiple cystic tuberculosis of bones shows two typical roentgen pictures which are valuable in diagnosis. The diffuse picture is seen in the acute early stage. The bone cannot be differentiated into medulla and cortex. There are

cystic areas of decreased density with a network of lines of increased density. The meshes of the network vary from the size of a millet seed to that of a pea. The cystic areas may enlarge to include both medulla and cortex, increase the diameter of the affected bone and even destroy it if it is a small one, such as a phalanx. In the circumscribed form the roentgenogram shows round punched-out areas of decreased density with a thin cortex and little or no surrounding sclerosis.

A case in a girl six years of age when she came for treatment which was followed up with serial roentgenograms for four years is described and illustrated. The roentgenograms show the process of healing that took place during four years of treatment. There were 35 rarefied areas in 22 different bones, none of them in the small bones of the hands or feet. In 11 of the lesions there was slight or moderate surrounding sclerosis. Reparation took place uniformly in most of the affected areas.—*Audrey G. Morgan.*

VAN BOGAERT, LUDO. Sur les arthropathies mutilantes symétriques des extrémitiés inférieures et leurs rapports avec la syringomyélie. (Symmetrical mutilating arthropathies of the lower limbs and their relation to syringomyelia.) *Presse méd.*, Dec. 17, 1940, *48*, 1026–1030.

Guillain called attention to syringomyelia of the lumbosacral region which produces mutilation of the lower extremities. In this article the author describes cases in three brothers, one of which at least is very similar to Guillain's cases. Guillain suggested peripheral infection as the cause of the disease, while the author thinks it is a constitutional disease.

The first patient, a man aged fifty-two, had suffered a slowly progressive deformity of the toes and tarsus on both sides. The foot was shortened and walking was painful. The feet were flat. He had a slight cervicodorsal kyphosis without scoliosis. There were numerous lipomata on various parts of his body. Though his serological reactions were negative he had been treated for a long time for syphilitic arthropathy. For the past ten years trophic disturbances, callosities, sweating, hypertrichosis and cyanosis had been increasing. At present neurological examination is negative except for anesthesia to heat over the great toes and the anterior part of the internal and external borders of the foot. Roentgenograms showed ankylosis of the joints and atrophy of the bones of the foot. The shortening of the foot was due to metatarsophalangeal osteolysis.

This patient's brother, fifty years of age, had had lancinating pains in the lower limbs since he was twenty years of age and walking was painful. At the time of examination he had perforating plantar ulcer of the right foot and trophic ulcers of the left hand with a typical glove-shaped syringomyelic dissociation on both hands and asymmetry of the two halves of the body.

A third brother, forty-six years of age, had talipes cavus with healed perforating ulcer, bilateral abolition of the Achilles tendon reflexes and hypesthesia to heat of the feet in the same localization as that of his brother. The roentgenogram did not show any bone lesions in either of the two latter cases.

A sister also had very short flat feet without perforating ulcer, with no disturbances of sensation, with enormous kyphoscoliosis and asymmetry of the body. Her daughter had trophic disturbances resembling sclerodermia of the nails, an aplasia of the clavicular segment of the pectoral muscle and of the periscapular muscles and slight kyphosis.

The author thinks these various anomalies were due to lumbosacral syringomyelia and that the family constitution played a definite part in their etiology. In this family the leading trait was the trophoneurotic disturbances, either of skin, muscles or bones and joints. In another family described in 1934 rapidly developing tumors were the most prominent feature, and one of the patients also had a non-angiomatous cerebellar cyst. But in the family described here the familial perforating ulcer was a form of syringomyelia and the trophoneurotic syndrome the most prominent of the symptoms. —*Audrey G. Morgan.*

DUBAU, R., and BOLOT, F. Diagnostic précoce de la tuberculose du genou chez l'adulte jeune; ses difficultés, les éléments les plus fidèles du diagnostic. (Early diagnosis of tuberculosis of the knee in the young adult: its difficulties and the most reliable points in diagnosis.) *Presse méd.*, Dec. 17, 1940, *48*, 1031–1033.

The author discusses 106 patients hospitalized since 1930 with a diagnosis of early tuberculosis of the knee. Only 69 of these were proved to be tuberculous, the other 37 were found to have non-tuberculous conditions.

It is generally very difficult to make a diag-

nosis of tuberculosis of the knee early in the course of the disease but it is very important to make it as soon as possible, as immobilization is indicated in these cases and mobilization in non-tuberculous cases.

Pulmonary tuberculosis is rarely found in these cases but roentgen examination may show pachypleuritis. In 37 of the cases there was an associated tuberculosis in some other region of the body.

Roentgen examination of the bones is of little value early in the disease but there is one very important early roentgen sign, namely, injection of the subquadricipital synovial cul-de-sac. The roentgenogram should be taken in strict profile and with soft rays so as to demonstrate the soft parts. This sign was lacking in only 9 of the 69 cases and in 4 of these there was a trace of it; the lack of greater definiteness was due to faulty technique—asymmetrical roentgenograms or ones made with too hard rays. The author has seen it positive in only three non-tuberculous cases; these were cases of voluminous hemarthrosis in which the history of recent injury left no doubt of the diagnosis. This is an excellent early sign but later in the course of the disease it is lost in the general edema of the soft parts.

Histological examination may show definite evidence of tuberculosis but the picture is not pathognomonic. The final definite proof is the demonstration of tubercle bacilli. If they cannot be demonstrated elsewhere it is justifiable to open the joint and do a synovial biopsy. This may seem a risky procedure but the author has found that if carefully conducted it is not dangerous. He also emphasizes the importance of examining the stomach contents for tubercle bacilli.—*Audrey G. Morgan.*

DUBAU, R., and BOLOT, F. Sur onze observations de tuberculose sous-astragalienn chez l'adulte jeune. (Eleven cases of subastragaloid tuberculosis in young adults.) *Presse méd.*, May 21, 1940, *48*, 519–521.

Among 30 cases of tuberculosis of the foot 11, or 36.6 per cent, were subastragaloid. Among these, 5 were anterior subastragaloid with involvement of the astragaloscaphoid joint, 2 were of the posterior astragalocalcanean joint alone and 4 of this joint and the tibiotarsal. The anterior and posterior astragalocalcanean joints are distinctly separate from each other, each having its own synovial membrane.

Involvement of these joints generally begins with pain and limping. Clinical examination shows swelling around the lesion. If it is the anterior joint that is involved this swelling is midtarsal; it extends backward if the lesion is in the posterior joint.

Diagnosis of the nature of the lesion is made from the history and examination for tubercle bacilli. Among the 30 cases of tuberculosis of the foot studied 21 had tuberculosis in other locations; among the 11 cases of subastragaloid tuberculosis 9 had tuberculosis in other localizations. The course is chronic and may end in fistulization.

Roentgen examination is apt to show diffuse decalcification of the tarsus which is not pathognomonic of this condition. A very characteristic roentgen sign is thinning of the joint line; this is most clearly seen in the posterior localization. Indistinctness of the joint interline is an excellent early symptom. Injection of the synovial membrane is seen in this localization as well as at the knee. The roentgenogram shows the joint capped with a projecting border which represents the injected synovial membrane. This border appears in front of the interline if the tibiotarsal joint is involved, on the dorsal surface of the astragaloscaphoid interline if Chopart's joint is involved and back of the interline if the posterior subastragaloid joint is affected. The course of the disease can be followed up by successive roentgenograms. If an adjoining joint becomes affected it can be detected in the beginning. At the height of the disease the roentgenogram shows the joint surfaces eroded and irregular. The image of the synovial membrane disappears in the edema of the periarticular soft parts.

The general disease should be given the general treatment for tuberculosis. The joint should be immobilized as soon as possible. If this fails or complications develop surgery becomes necessary. A radical Syme's amputation may be necessary or a conservative operation designed to establish ankylosis in a good position may be sufficient. The author describes and illustrates with roentgenograms a conservative operation which he has used successfully in 2 cases. A graft from the crest of the tibia 6 cm. in length is inserted downward and backward from the neck of the astragalus to the posteroexternal tuberosity of the calcaneum. The course of the graft can be followed up under the screen. In his 2 cases both the immediate and late results were satisfactory and the patients can walk without pain.—*Audrey G. Morgan.*